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TECHNICAL NOTE

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Land Management

U.S. DEPARTMENT OF AGRICULTURE
U.S. Forest Service

WILD, FREE-ROAMING HORSES - STATUS OF PRESENT KNOWLEDGE

by Mark Zarn, Thomas Heller and
Kay Collins, Research Biologist
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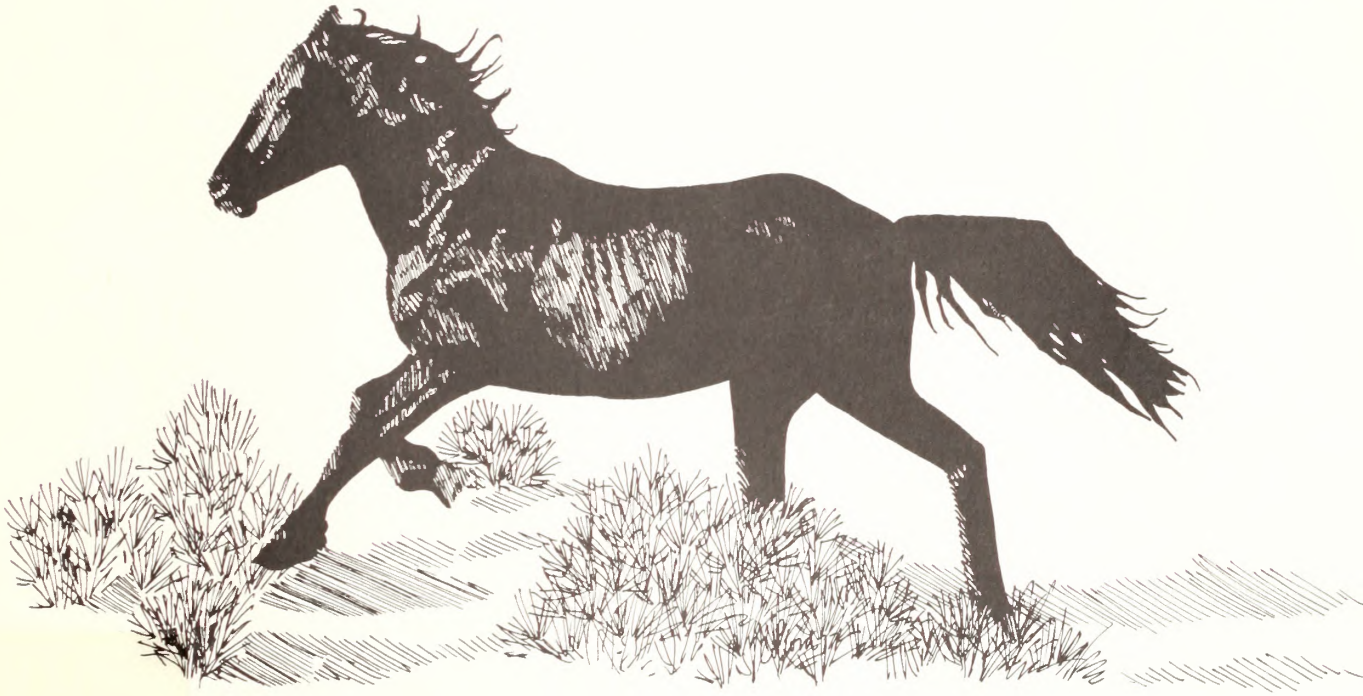

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Introduction

The purpose of this report is to provide personnel of the U. S. Forest Service and U. S. Bureau of Land Management with a literature review and summary of available information on wild horses.

The scientific and recorded factual information on America's wild horses is extremely limited. Klingel (1972), who has spent many years studying the wild Equidae of Africa, states that, except for social organization, all members of the genus are very much alike. As a result, many portions of this technical note were summarized from data on domestic horses or from data on other members of the Equidae. Therefore, the validity of much of the information as it applies to America's wild horses will have to stand the test of future research.

Only a relatively small number of people know very much about wild horses. Certain individuals such as ranchers and those few who have chased them, lived near, or been around them all their lives often possess a remarkable store of knowledge on their habits and general ecology. Thus, there is a considerable amount of anecdotal information that cannot be quoted because it cannot be verified.

The problems of management are extremely complicated. We are not dealing with a homogenous population of wild animals. At the extremes are those horses that have been in the wild for many generations and are capable of surviving under the harshest of conditions. At the other end are those animals only a step or two away from domestication that have not as yet fully adapted to their environment. Management of horses as truly wild animals would consider little or no interference by man; however, this approach could be hazardous and is almost an impossibility under the increasing pressures for various land uses. Other types of management, related to game animals or to livestock, are hamstrung by lack of biological data and may be restricted by special interest groups or the emotional issues involved.

Species Description

General. The family Equidae, to which the horse belongs, also includes donkeys, zebras, onagers and all their ancestors back to eohippus. All the living Equidae represent a single genus, Equus, with six species. Domestic horses and their wild relatives form one species; the asses, both domestic and wild, another; the onagers a third; zebras comprise the other three species.

The genus Equus includes all members of the family Equidae and their immediate ancestors during the last Ice Age. Equus caballus includes only the domestic horse and wild relatives so closely related to it that they are capable of interbreeding and producing fertile offspring (Simpson, 1951).

The andulusian horse that came to America was reconstructed from old paintings and records by Cabrera. The animal was small to medium in type, rather close to the ground, had a wide chest, ample barrel, a muscular, rather short neck, and a rounded sloping croup with a low-set tail. The latter two characteristics are also typical of Barb points (Simpson, 1951).

The Spanish Barb Wild Horse Research Farm describes the Barb: it is small (under 14 hands) and weighs about 800 pounds. The front legs join the deep narrow chest in a reversed V. The withers are low. The ergots are small or non-existent, the chestnuts small, smooth, and soft and do not peel as they do on draft breeds. The croup is low with the back legs well under it. The back is short with 17 pairs of ribs and either five lumbar vertebrae or the sixth fused to the fifth. The head is small, not over 18 inches from the pole to the end of the nasal bone. The ears are small, rimmed with black; light hair grows out of the center of the ear. The muzzle is also small and has crescent-shaped nostrils.

Colors are solid, roan, or grulla, which shades from slate to mouse brown. The mane, tail, hooves and legs below the knee are black. The hair on the back of the legs grows in a curl and comb.

The present-day wild horse, due to many years of cross breeding with abandoned, lost or stolen domestic breeds is, in most cases, little different than any other domestic light horse (Beebe and Johnson, 1964). Ryden (1970) states that there are only a few hundred pure-blooded descendants of the original Spanish horses and these are in captivity in special registers in North and South America. She also states that the Spanish horse's traits often appear in animals that have as little as 3.0 percent Spanish ancestry.

The significance of the number of lumbar vertebrae to determine whether a horse has Spanish ancestry or not is open to question. Stecher (1962) studied the lateral joints in the caudal lumbar region of horses. He examined the skeletal remains of 245 horses of nine species obtained from various sources. The horses were classified according to whether they had five or six lumbar vertebrae. Skeletal specimens included the domestic horse, the arabian, the shetland pony, Przewalski's horse, the hybrid mule, two species of asses and two of zebras. The shetland pony was the only species in which all samples (eight)

contained six lumbar vertebrae; the Hemoine (Equus hemoinus), the Mongolian wild ass, was the only species in which all samples (nine) contained five lumbar vertebrae. Skeletons of ten arabians showed three with five and seven with six vertebrae. Two domestic horses had five and one half, and one Grevy's zebra (Equus grevyi) had seven lumbar vertebrae.

Edwards (1970) states that arabian horses, regardless of their purity, do not always have five lumbar vertebrae any more than Przewalski's horse always had five or six. It depended on who you were talking to.

Howell (1945) wrote that the American Museum of Natural History stated in a letter to him that the proper number of lumbar vertebrae for the arabian is five while that of other horses is six. The statement was qualified by stating that the point which constitutes a lumbar vertebrae is its transverse processes whereas a dorsal vertebrae is determined by the attachments of ribs in place of transverse processes. Therefore, it is safer to say that arab horses have 23 dorso-lumbars while other varieties have 24.

Feist (1971) and Hall (1972) reported skeletal examples of three types of lumbar vertebrae in the Pryor Mountain horses. The Barb type have five lumbar vertebrae and 17 pairs of ribs; the Andulusian have five and a half, with the last three fused; and the modern breeds of today (except the Arabian) have six lumbar vertebrae with no fusion. Appendix 2 depicts three types of lumbar vertebrae found in equids.

Colors. Since local color names vary from one geographical area to another, it is difficult to portray true horse colors verbally.

The original Andulusian horse encompasses the entire range of horse colors. Spotting occurs, but is not especially characteristic (Simpson, 1951). Smith (1841) wrote that all South American feral horses bore the stamp of the domesticated races of old Spain. His personal observations indicated that they were mostly of similar color though every color seen in Europe existed among them. Grey, or shades of grey, were most common in the northern mountain regions, and shades of bay in the pampas. Black was the rarest color. Hoyt (1886), an old mustanger, wrote that ninety percent of the feral horses on the panhandle of Texas were bay, dark brown, or black, and that other colors were rare. Cook (1919), writing in 1870, stated that on the plains area east of the Rockies, color in wild mustangs consisted of cream, buckskin or mouse and that black stripes above the knees or hocks and along the middle of the back from mane to tail commonly occurred. Worcester (1945, p. 416), in an historical review of Spanish horses among the

Indians, stated that David Thompson, an early explorer, commented on hoof color in Indian horses: "The yellow hoof with white hair is a brittle hoof and soon wears away; for this reason, as much as possible, the natives take only black-hoofed horses on their war expeditions."

Gremmel (1939), writing in the Journal of Heredity, stresses physical differences in horse coat colors from an histological point of view. He lists the basic colors and the patterns that occur within these basics (see Appendix 3).

Dobie (1952) devoted a chapter to the dun color in wild horses (p. 299):

> The dun and the stripe are always waiting to come back. All colors but gray and roan are, in biological language, recessive to dun. I cannot draw up tables of dates and numbers, but to me it is evident that for three and a half centuries, say from 1520 to 1880, dun was progressively emerging over the American continents among descendents of horses marked sparsely by that color when Spaniards planted them. Before that time selective breeding had driven the dun color into hiding; feral life brought it back.

There is a wild coat pattern gene in horses. Przewalski's horse is not uniform black but has a distinctly concealing color. The general body color is a neutral gray but peripheral areas, including mane, tail, dorsal stripe and legs, are black. The primitive type coat color depends upon four dominant genes. Recessive mutations have modified each of them. However, they form the basis of domestic color varieties, many of which would be unable to survive in wild populations because they lack concealing value (Castle, 1954). Feist (1971) listed eight basic colors for the Pryor Mountain horses. Variations to these basics that appear on legs, manes or tails were classified as secondary markings. Hall (1972, p. 19) noted that the Pryor Mountain herd seemed to be reverting back to the original mustang type. Among other characteristics he refers to color. "The reversion of colors to the blue corn, buckskins, and bays with line stripes down their back, along their withers and on their legs."

There are many reports that stallions often show color preferences for the mares they select for their harems and will reject those whose color does not meet their requirements (Dobie, 1952; Feist, 1971; Ryden, 1970). Since color vision has not been scientifically established in horses (Hafez, et al, 1969; Smythe, 1966), the selection of certain colored mares may be based on brightness or intensity rather than hue.

Size of horses. There are no extensive records of wild horse sizes or weights. The original Spanish horse was small, rarely attaining 15 hands. Some of the Indian mounts reached only 12 to 13 hands. Present-day stallions seldom exceed 1000 pounds, and mares may be as light as 700 pounds (Ryden, 1970). In the Pryor Mountain herd, females averaged 600 to 750 pounds and males, 800 to 850 pounds (Hall, 1972). Cook (1919), who wrote of the period from 1870 to 1880, estimated that the average wild horse weighed about 800 pounds. Schwartz (1949) reported that wild horses sold to fox ranches and other outlets that buy horses for slaughter averaged between 750 and 850 pounds but some of them weighed as much as 1250 pounds. Horses from the North often weighed more than those from the South due to more draft blood from escapees of the World War I period; however, the horses in certain parts of Oregon were small, averaging 800 pounds in weight. The Fort Apache herds, which had as high a percentage of wild mustang blood as any, averaged about 650 to 700 pounds (Wyman, 1945).

A factor affecting the growth of wild horses, and one of the reasons many of them remain smaller than domestic horses, is their restricted diet. They rarely eat grain like domestic horses, and their diet is often deficient in minerals and vitamins, plus the fact that salt and adequate water are not always available to them (Beebe and Johnson, 1964). Other writers also mention inadequate and poor quality of food as a reason for the small size of wild horses (Ensminger, 1951; Hall, 1972; Ryden, 1970).

The maturation rate in wild horses is slower than in domestic horses. Two- and three-year-old horses often appear to be yearlings (Ryden, 1970; Hall, 1972).

Length of life in wild horses. There is little data on the lifespan of horses in the wild state. Domestic horses that reach their twenties are considered old; however, it is not uncommon for horses to reach their thirties and some have been recorded that survived past forty years of age (Simpson, 1951). The maximum life span of horses in the Pryor Mountains is ten to fourteen years and their maximum breeding period is five to six years (Hall, 1972). Dobie (1952) relates that Black Kettle, a famous and legendary wild horse that was captured past his prime, lived to about thirty years of age.

Aging horses. The age of horses is generally determined by the amount of wear of their teeth. The mature male has forty teeth; a young animal, male or female, has twenty-four teeth. The mature female lacks tushes and therefore has thirty-six teeth. In horses up to five years of age the numbers of permanent and milk teeth are noted. From six to twelve years, age is estimated by the number of cups or indentations in the

incisor teeth. After twelve years, age may be judged by the cross section and slant of the incisors. Learning to determine age in horses is a matter of practical experience. When a horse exceeds twelve years, even the most experienced investigators have difficulty in determining accurate age (Ensminger, 1951). Horses that live in areas of sandy or gritty soils show increased dental wear. Under these conditions a six-year-old horse may appear to be ten years old (Bone, 1964).

Locomotion. It is only since the development of the camera that man has learned accurately how a horse coordinates its four legs during execution of the various speeds of movement.

Horsemen recognize as many as twelve gaits in horses, but these are all variations of the walk, trot, pace and gallop. The pace is included because a few horses pace naturally. The canter, which is a slow gallop, usually has to be taught. The lope, recognized by western horsemen, is a smooth gallop or canter which sometimes verges on a four-beat rhythm similar to a running walk.

The walk has a four-beat cadence with the succession of footfalls being left-fore, right-hind, right-fore, left-hind. The body is alternately supported on three and on two legs. The trot is a faster gait with a two-beat cadence where the diagonal legs move together so that the sequence of feet striking the ground is left-fore, right-hind followed by right-fore, left-hind. Twice in each stride there is an interval when all four feet are off the ground. The pace has similar rhythm to the trot but the two legs of the same side, not the diagonals, move together. It is a slow, broken pace tending toward a walk.

The gallop is the horse's fastest gait and differs from the others in not being symmetrical on the two sides. It may be led either on one side or the other. The cadence is three beat, with a broken rhythm that occurs as beat, pause, beat, quick double beat, beat, pause, etc. The pause represents the short period when all four feet are off the ground, which occurs only once in each stride. The sequence of footfall for the left lead is left-fore, right-hind, left-hind and right-fore, the latter two almost together with the hind foot slightly ahead. The right-hind foot is lifted almost immediately as the left hind foot comes down and before the right fore foot strikes. Normally, at no time are three of the horse's feet on the ground. The right lead is a mirror image of the left lead. In an extended gallop there may be four beats, as opposed hind and fore feet strike at perceptible intervals; however, the break after the placing of the lead foot still distinguishes the cadence. Horses can be taught to lead either right or left or to change from one lead to the other while galloping. This is important if the animal is to turn rapidly, because a horse

making a sharp left turn on the right lead is liable to fall (Simpson, 1951; Tricker and Tricker, 1966).

Few horses jump regularly unless they are taught. This may be due in part to their lack of binocular vision which prevents them from judging the correct take-off distances (Hafez et al, 1969).

Drawings from a motion picture strip (Appendix 4) depict leg positions of the horse while walking, trotting and galloping.

Population Characteristics

Some of the properties of a collective group of organisms or populations are density, birth rate, death rate, age distribution, biotic potential, dispersion and growth form. Genetic characteristics such as adaptiveness, reproductive fitness, and persistence (leaving descendants over long periods of time) are also directly related to populations (Odum, 1971).

There are three major age groups in a population, the pre-reproductive, the reproductive and the post-reproductive. In a rapidly growing population, growth may be exponential due to a high birthrate and each successive generation will be more numerous. This results graphically in a pyramid age structure. The graphic representation of a stable population is bell shaped. The pre-reproductive and reproductive age groups are fairly equal in size and the post-reproductive age group remains small. If the birth rate is drastically reduced the reproductive, post-reproductive age groups increase proportionally which results in an urn-shaped graph representative of a declining population (Boughey, 1968).

Odum (1971) describes characteristics of populations in regard to age structure. An expanding population contains a large proportion of young animals; a stationary population a more even distribution of age classes; a declining population a large proportion of old individuals.

The population density of wild horses, like that of any other animals, must be in tune with and not exceed the carrying capacity of the available habitat. Other than this general observation and the limited data that Hall (1972) and Feist (1971) collected on the Pryor Mountain horses, there is no scientific information available on optimum population levels, the results of overcrowding, competition, or the effects of a degrading habitat. However, there is evidence that wild horse densities could be reduced, through improper management and control, to a level that could lead to their extinction either locally or nationally.

There is a critical population size that varies from species to species. Once the population density of a particular species goes below this level it is doomed to extinction regardless of efforts to save it. Prime examples are the passenger pigeon which died out completely even though hunting had ceased and there were still several thousand remaining birds scattered over North America; the Heath hen, although rigorously protected (after the population level had become small), suffered the same fate.

Since their social life plays an important part in locating feeding areas, raising their young and defending against enemies, gregarious animals such as the ungulates are particularly susceptible to the danger of extinction when their density reaches a certain level. A number of factors may determine this critical population size. Three of the more important of these are: (1) males fail to find females due to low density, (2) courtship behavior is inhibited by local low population density, (3) the remaining population is too small to resist predators and competitors (Ziswiler, 1967). Erhenfeld (1972) adds another factor: the population size may be too small for reproduction to compensate for losses from disease, climatic conditions, or natural disasters.

Distribution of Wild Horses

The public land administered by the Bureau of Land Management and the U. S. Forest Service that contain habitat for wild horses are located in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming. The largest concentrations of wild horses are in Nevada, Wyoming and Oregon.

Their distribution is generally limited to areas where accessibility is limited, population of humans is sparse, and the terrain rugged. Their range is also limited by availability of forage, water and the numbers of fences or barriers that restrict movement. The total extent of wild horse habitat on lands not federally administered is not known. Thousands of acres of these lands are not fenced and the wild horses have access to them.

Populations of wild horses in the grassland biome are small, a few have been reported in New Mexico and in Montana. The greatest numbers inhabit the cold desert and the pinon-juniper type of the woodland-brushland biome. Seasonally, in some areas they range into the montane coniferous forest biome. In general this biome is too cold in the winter for the horses to remain there year round. See map, appendix 8.

Population Status

The proceedings of the first National Advisory Board meeting for wild horses and burros (January 1973) reported an estimated total of 2000 horses on Forest Service controlled lands and 16,878 horses on Bureau of Land Management controlled lands.

Both agencies state that 1975 population estimates, as presented below, are of much higher quality than their earlier data due primarily to more intensive efforts and improved methods of censusing. Bureau of Land Management controlled lands are listed by state; Forest Service lands by forest region. Data on state, private and other lands is not available. (See map, Appendix 8).

Bureau of Land Management Wild Horse Inventory Data as of May 1, 1975
(Prepared by Milton Frei, U.S. Bureau of Land Mgt., Denver, Colo.)

Estimates of Population

State	Horses	Animals Claimed
Arizona	109	4
California	3,373	321
Colorado	697	-
Idaho	865	14
Montana	314	110
New Mexico	6,543	6,463
Nevada	21,868	5,268
Oregon	6,928	1,209
Utah	1,670	1
Wyoming	7,291	725
	49,658*	14,115

* Includes animals claimed, proof of ownership still has to be determined under Section 5 of the 1971 Wild Horse and Burro Act

National Forest Wild Free-Roaming Horse Inventory Data (Estimate)
(Adapted from a letter dated April 15, 1975, from the Assistant Director for Environmental Coordination, U.S. Forest Service)

Region	National Forest	Population as of 1-1-75	No. of Animals Claimed
1	Custer	8	
	Region Total	8	
2	Shoshone-Bridger	7	
	Region Total	7	
3	Apache-Sitgreaves	7	
	Carson	161	
	Gila	6	
	Santa Fe	60	
	Region Total	234	
4	Challis	3	
	Payette	13	13
	Dixie	60	
	Wasatch	20	
	Humboldt	485	
	Toiyabe	812	16
	Region Total	1,393	29
5	Klamath	22	
	Lassen	50	
	Modoc	500	
	Los Padres	9	
	Inyo	298	
	Region Total	879	
6	Malheur	174	44
	Ochoco	60	1
	Region Total	234	45
	GRAND TOTAL	2,755	74

Origin and History of Wild Horses

Origin. Present-day horses of all kinds have descended from a small, four-toed, rodent-like creature whose name many people are familiar with, eohippus, or the dawn horse. The correct scientific name, however, is Hyracotherium. This came about because early scientists (1838) did not recognize that the fossil remains of a small animal found near Suffolk, England was related to horses, and compared the remains to the Hyraxes, which the fossils closely resembled. Hyraxes are comparable in size and external appearance to rodents and lagomorphs. When similar fossils were found in North America at a later date the principle of evolution had become well established and they were recognized as horse ancestors. Charles Marsh of Yale University gave them the euphonius name, eohippus. Since Hyracotherium is much the older of the two names, under the rules of zoological nomenclature it is the correct one to use.

Eohippus lived at the same time in both Europe and North America, appearing in both places at the very beginning of the Eocene. No direct ancestors of eohippus have been found on either continent. There were several species of eohippus which varied greatly in size, the smallest being not much over 10 inches in height at the shoulder, the largest about 20 inches. Four toes occurred on the front foot of eohippus, each ending in a separate small hoof. The hind foot had only three functional toes. The animal was already distinctly herbivorous, with teeth modified for browsing rather than grazing (Simpson, 1951).

In the beginning of the Cenozoic Era of geologic time (70 to 75 million years ago) the British Isles and North America were attached as part of the supercontinent of Laurasia, which also included Greenland and Europe north of the Alps and east to the Himalayas. During the long period when Laurasia was separating, animals were able to migrate back and forth on the land bridges that still connected Europe and North America. During this time eohippus evolved and occupied both North America and Europe. Not long after this the continents separated and migration ceased. In Europe for an unknown reason eohippus became extinct. In North America through a period of about fifty million years eohippus evolved into Mercyhippus, an animal with high crowned teeth which permitted it to graze rather than browse. It was also larger, about the size of a small pony of today.

After Mercyhippus there is a gap in the fossil records from about six million years ago to about 600,000 B.C., during which time Mercyhippus evolved into Equus caballus, the true horse, having a single toe on each foot. No fossil remains of horses have been found in North America for the pleistocene epoch, the Great Ice Age. The scanty records that were available came mostly from Eurasia. Perhaps when the ice melted, fossil records

were washed away in the huge floods that followed. Equus caballus may have evolved from some of its North American ancestors that crossed the land bridge which connected Alaska and Siberia during this period. Changes in conditions which are still unclear brought the horse back to North America about 600,000 B.C. Fossil records dating from this time to about 7000 B.C. have been found in many places on the North American continent. After 7000 B.C., horses again vanished along with several other species of large grasseaters. There was no such extinction of species in Europe. As the ice sheet melted, Europe warmed and the forests encroached on the grasslands. Grazing herds were forced eastward onto the steppes of southern Russia and western Asia. Tribes of early hunters followed the herds, became semi-nomadic and by 5000 B.C. had hunting dogs and had domesticated the onager (Asian wild ass) and reindeer (Simpson, 1951; Haines, 1971). Appendix 5 depicts features of horse evolution.

Domestication of the horse. By about 4000 B.C. two, and possibly three, species of E. caballus had developed in the Eurasian grasslands. Around the Black and Caspian Seas the "Tarpan" and in Mongolia or Manchuria Przewalski's horse had developed. A third subspecies, depicted as a forest horse, was larger than the other two and existed in Polish forests until the middle of the eighteenth century. Disagreement exists as to whether it was a true subspecies.

Truly wild horses were common from Europe through central Asia in early historic times. The European breed called "Tarpan" is now extinct and it is uncertain if Przewalski's horse survives in pure form. There is general agreement, however, that the "Tarpan" was the first domesticated horse.

Later, Indo-Europeans invaded the region from the southeast and possibly tamed a few horses. By 4000 B.C. they were using horses to pull carts. Horse culture spread north and east into Mongolia and turned many tribes into nomads. About 2000 B.C. tribesmen from the Asian steppes crossed the Iranian plateau with horses and overran the entire near east. A thousand years later horses appeared in North Africa, west to Gibraltar, and north and west through Europe as far as Scandinavia, Spain, France, and the British Isles. The earliest records of horses in Greece appear about 1700 B.C., in Egypt, 1600 B.C. and in India, 1500 B.C. By 1000 B.C., and possibly earlier, they had reached Spain. The first horses that were imported from north of the Caucasus were small, stocky animals, more commonly used for pulling carts and chariots than riding. Later the Egyptians involved in trading and breeding horses crossed these with the more fleet horses that came from the Libyans or Numidians of North Africa.

There are several theories concerning the development of modern horses. One of the most popular at present is that all the light, fast, Mediterranean and mideastern horses arose from a single original stock now represented by the Arabian. If this is true, the Numidian horses now represented by the Barb (named from Barbary, an old African country west of Libya) were of common origin with the Arabian. The Barb and Arabian, however, as far back as they can be traced, are of distinct types. They are both light and fast, but the former lacks the wedge-shaped head, the dished profile and protruding eyes of the Arabian. Both supposedly have 23 lumbar vertebrae, whereas 24 is the usual number in all other breeds.

A heavy horse capable of carrying armored knights was first developed in Germany, France and the British Isles. The early horse of Spain was a heavy breed similar to those used in France and Germany. When the Moors invaded and conquered Spain, the Spaniards recognized the superiority of Moor horses which were mostly Barb with perhaps some mix of Arabian. They crossed their own Norse Dun breed with the Barb-Arabian mixture. The product, called the Jennet, was so superior that for the next several centuries Spain was renowned for the quality of its horses, especially those from the Andulusia area of Spain.

The Andulusian type is the breed that was first brought to the new world by Spanish conquistadors. Later it escaped onto our western plains and the pampas of South America and became the wild horse of the West and of Argentina (Simpson, 1951; Ryden, 1970; Haines, 1971).

Influence of horses on history. Since their domestication, horses have had a profound influence on history. Perhaps the most significant has been the use of horses in warfare. They have been involved in every war up until recent times, and only within the present century has the development of horses for military use ceased to be the main concern of breeders.

The Mohammedan and Mongolian conquests were made possible by horses. In the seventeenth century the Mohammedans were stopped by the Franks only because the Franks were clad in armor and mounted on heavy, strong horses. The Mongolians were never really stopped; their empire collapsed because of its unwieldy size.

Horses since ancient time have been important sources of power for agriculture and transportation, for recreation, as status symbols or emblems of wealth and authority, for food, leather, and other products. The horse is still essential as a source of rural power and transportation in many countries.

The American nation was built on horsepower and even today, when the horse is no longer essential, it remains a part of our culture. The mechanized age lessened the importance of the horse as a principle factor in American development, but it still has use for riding, hunting, recreation and as an animal that people like to be associated with (Simpson, 1951).

The horse in America. It is difficult to state flatly how or where horses first escaped or were stolen from the Spaniards and reverted to a wild state. On Columbus' second voyage in 1493 he landed horses from Andulusia in the West Indies. Ponce de Leon brought horses from Cuba or Puerto Rico to the coast of Florida in 1521. Cortez carried horses with him when he discovered the Aztec civilization in 1519. Horses were introduced into the pampas of South America by Pedro Mendoza in 1535. However, it is likely that wild horses which later covered the pampas came from Chile and not from the small number Mendoza abandoned. During the early years of exploration, horses were sent in nearly every ship leaving Spanish ports. The Spaniards also established breeding farms in the West Indian colonies of Cuba, Puerto Rico and Santo Domingo, and stocked them with the finest stallions and brood mares that had been brought out of Spain. So many horses were transported that Spain finally placed an embargo on the animals because they lacked enough horses for home use. At one critical point horses were in such short supply that the breeding farms in the West Indies were forced to import more Barbs from North Africa, thus the Barb was once again introduced into the line (Simpson, 1951; Ryden, 1970; Haines, 1971).

Indian tribes in Texas and New Mexico were probably the first to obtain horses. The Apaches and Comanches got horses by raiding the Spanish camps; they sold or bartered horses to other tribes as did Spanish and French traders. Soon horses spread to the Navajos, Zunis, Utes, and other tribes in the Southwest and thence to tribes in the southern plains and northern plains. By 1750 even the Blackfoot Indians in Canada had horses (Smith, 1969).

There are no reliable estimates of the number of feral horses in the U. S. during the late 1700's to early 1800's. This was the time of maximum horse population. McKnight (1959) estimates anywhere between 2 and 5 million. The greatest numbers occurred in the Southwest, with the most densely populated ranges in west central Texas.

The introduction of barbed wire and fencing marked the end of the wild horses on the Great Plains and significantly reduced their numbers elsewhere. At the end of the 19th century most wild horse concentrations were to be found west of the Rocky Mountains.

The Boer War in South Africa created a large demand for horses. Thousands of wild horses were caught and shipped to Africa, and since many died en route or were killed in action, the demand continued until the war ended in 1902. During World War I, amateur and professional horse hunters found they could sell all the wild horses they could catch.

In the early 1920's four new markets developed that helped further decrease wild horse herds: the use of horse meat for chicken feed, pet foods, human food and an increase in horse use by southern farmers when cotton prices dropped and tractors became too expensive. The demand was partly supplied by trained mustangs captured from wild bands.

The blood of remaining wild herds was further diluted during the depression of the thirties. Large numbers of marginal farmers and ranchers went out of business. These early settlers, unable to sell their domestic horses, released or abandoned them. Many of these joined the roving bands of wild horses.

The passage of the Taylor Grazing Act in 1934 also affected wild horses, since stockmen became reluctant to share their assigned grazing areas with wild horses. As a result, ranchers, professional horse catchers, and the federal agencies cooperated on drives to remove the horses. When this Act became law it was estimated that there were some 150,000 wild horses remaining on public lands in the eleven western states.

World War II brought temporary relief but after the war, efforts to rid the range of wild horses was again initiated. During the late 1940's and 50's, over 100,000 horses were removed from Nevada rangelands, while smaller numbers were removed from other western ranges (Denhardt, 1948; McKnight, 1959; Smith, 1969; Ryden, 1970). (See historical distribution of wild horses, Appendix 7)

The wild horse controversy. The controversy over wild horses simmered for many years. Public concern for the plight of the wild horse gradually increased as people became aware that the methods of capture were barbarous, the treatment brutal and inhumane, and the final product, pet or chicken food. During the 1920's chicken feed producers in California persuaded the railroads to ship horses as "chicken feed" thus eliminating the need for humane treatment during transit.

One of the results, and the primary one, was a rash of articles and stories in national magazines and in the news media about wild horses. Millions of people who had never heard of wild horses were now concerned and they reacted by writing letters to their elected representatives (McKnight, 1959).

Several different philosophies concerning wild horses emerged. One group, including many stockmen and trained scientists do not consider the wild horse wild. They claim it is a mixture of many breeds of the domestic horse--that the blood of the original Spanish horse is so diluted as to be almost nonexistent. They also consider it a nuisance and a pest. Another group favors native wildlife and where there is competition they feel that the horse should be removed or rigidly controlled. A very large number of people view the wild horse as a symbol of the old West and that all wild horses should remain wherever they are. A more moderate group leans toward multiple use. They feel that the wild lands are for the use of all animals and that the condition of the land and vegetation has first priority but that there is a place for the wild horse. They are strongly opposed to brutality or inhumane treatment when populations have to be controlled (Crain, 1973; McKnight, 1959).

As a result of continued public concern, Congress has passed two federal laws to protect wild horses. Public Law 86-234, passed in 1959, prohibits pollution of water holes for trapping and the use of aircraft or motorized vehicles to capture or kill wild horses. Public Law 92-195, passed in 1971, places wild horses and burros roaming on national resource lands under the jurisdiction of the Secretaries of Interior and Agriculture for protection, management and control. It provides a penalty for harassing, capturing, killing or selling wild horses or burros and prohibits the processing of either animal into any commercial product. It also provides for the establishment of an advisory board to make recommendations to the Secretaries on management and protection of wild horses and burros. The above statute omits national parks and monuments.

The first advisory board, composed of nine members, met on four occasions during their initial year, 1973. Meetings were held in Salt Lake City, Utah; Denver, Colorado; Billings, Montana; and Lake Havasu City, Arizona. All of the meetings were open to the public. The members of the first advisory board are listed below:

Name	Address
Dr. Charles Wayne Cook	4800 Venturi Lane Fort Collins, CO 80521
Mrs. Velma Johnston	140 Greenstone Dr. Reno, NV 89503
Mrs. Paul Twyne	629 River Bend Rd. Great Falls, VA 22066

Dr. Roger Hungerford	University of Arizona Tucson, AZ 85721
Mr. Ed Pierson	Box E Laporte, CO 85035
Mr. Ben Glading	1413 El Tejon Way Sacramento, CA 95826
Dr. Floyd W. Frank	1395 Walenta Way Moscow, ID 83843
Mr. Roy Young	P. O. Box 588 Elko, NV 89801
Mr. Dean Prosser, Jr.	P. O. Box 206 Cheyenne, WY 82001

Reproduction

Sexual behavior in females. During diestrous, if the stallion attempts to mount, the mare displays defensive reactions varying from aggressiveness to disinterest. As estrous approaches, the mare may allow the stallion to smell and bite her. When ready to copulate, the tail is lifted and held to the side, the pelvis lowered and the hind legs spread. The intensity of estrous behavior varies between individual mares and peaks just before ovulation (Hafez et al, 1969). The behavior of adult pony mares in full estrous was usually passive after a stallion had shown interest. They stand quietly with hind legs straddled, tail raised and often turn their head to touch the stallion's muzzle. On occasions they squeal, urinate in small amounts or paw the air with the forefeet (Tyler, 1972).

Domestic mares generally show estrous at 15 to 24 months of age. The estrous periods recur at approximate 21-day intervals within a range of 18 to 27 days. The length of the estrous period varies from 5 to 8 days but may be longer in early spring. The average gestation period is 340 days plus or minus 30 days. Postpartum estrous usually occurs seven to eleven days after foaling (Ensminger, 1951).

Under domestication the average conception rate of horses is less than 50 percent. In the wild state, when horses had access to good forage and water it was not uncommon for the conception rate to be as high as 90 percent (Ensminger, 1951). The method of determining the conception rate for wild horses was not reported.

Within the body of literature on horses, there is inconsistency pertaining to the nature and length of the breeding seasons. The terms "polyestrous" and "breeding season" are often misinterpreted. Mares can be classified into three categories, monoestrous, true polyestrous and transitory polyestrous. Wild breeds are monoestrous. They exhibit several estrous cycles during a restricted breeding season that coincides with the longest days of the year. Wild mares may show sexual receptivity throughout the year but they do not necessarily breed all year round (Berliner, 1958; Hafez et al, 1969). Clegg and Ganong (1969) report that domestic mares will breed at any season if they are well fed. When mares are maintained on grass they frequently show anestrous during the winter. They suggest that nutritional factors are partly responsible. The mare is predominantly a spring breeder; therefore she would be expected to respond to increasing rather than decreasing day length (Clegg and Ganong, 1969). A wild mare will go barren until the following year if she is not bred in the spring or early summer (Feist, 1971).

Burkhardt (1947) studied the influence of light on the reproductive activity of domestic mares. He divided anestrous mares into four groups. One group received artificial illumination to increase day length. Another group was exposed to ultraviolet light applied to the flank and belly. The mares in this latter group had their eyes hooded. Estrous appeared in the group receiving extended day length about 30 days earlier than the control. The estrous cycle of those receiving light on the flank and belly was normal. The author suggested that since irradiation of the ovaries did not alter the estrous cycle, the receptor organ was probably the eye. Nishikawa et al (1952) exposed anestrous mares to increased day length from mid-November until the end of February. They concluded that light was a factor but not the only one controlling reproductive activity in mares.

Hall (1972) says that the majority of mares in the Pryor Mountain herd do not enter estrous until they are three years old. He does not think that these horses have adjusted their estrous cycles to the optimum period for foal survival. He relates reproductivity to nutrition since the first foals (1971 and 1972) were observed in April and the majority of the mares were through foaling by mid-July. When the horses have been on green spring forage a sufficient time for their nutritional state to improve they enter estrous. Their reproductive period starts at about four and ends at about nine years of age. Tyler (1972) reported that most pony mares foaled for the first time when three or four years old but some not until they were five years old. Very few of the 141 mares that were 3 years old or more foaled in each of the 3 years of study. Foaling in alternate years was common; so were abortions during the late autumn, winter and early spring.

Sexual behavior in the stallion. There are three distinct phases of sexual behavior in the stallion: courtship, erection and mounting, and intromission and ejaculation. Sex drive is manifested throughout the year. Courtship is important for successful mating because the stallion depends upon erotic stimuli to achieve vascular engorgement of the penis. This is elicited by visual, auditory, tactile, and olfactory sensory modalities. The relative importance of these varies among species (Hafez et al, 1962). During courtship the stallion, after smelling the mare, exhibits the flehmen posture and sometimes snorts or whinnies and nibbles or licks the mare before mounting (Hafez et al, 1969; Feist, 1971; Tyler, 1972). True precopulatory behavior of stallions was often very brief. Usually it was longer with young mares than with older, more experienced mares. The older mares also rejected sexual advances by colts and bit or kicked at them when they attempted sniffing. Adult stallions chased colts away from adult estrous mares but allowed them to copulate with young females up to 4 years of age (Tyler, 1972).

Blakeslee (1974) was told by the owners of the free-roaming appaloosa horses that they had observed only one instance of a foal being killed by a stallion, and this occurred in a fenced enclosure. Tyler (1972) stated that three stallions were probably responsible for the death of six foals and the injury of several others. She attributed these actions to frustration-induced aggression caused by mares (who were not in full estrous) rejecting the stallions' sexual advances.

Proper copulatory patterns are apparent in many stallions at 10 to 12 months of age. However, domestic stallions are generally not placed in service until three years of age (Ensminger, 1951; Hafez et al, 1962). In the Pryor Mountain herd, Hall (1972) states that the testes of stallions do not descend until they are three years of age.

Reproductive activity in the stallion, like the mare, is also influenced by light. Reduced light diminished the quantity and quality of semen whereas increased light produced an opposite reaction (Nishikawa et al, 1952).

Foaling. With normal presentation a domestic mare foals in fifteen to thirty minutes. The foal is usually born while the mare is lying on her side with her legs stretched out. In normal birth the front feet with heels down appear first, followed by the nose which rests on the front legs. The hind legs and feet are last (Ensminger, 1951).

Blakeslee (1974) reported that she was advised by the owners of the free-roaming appaloosa horses that any birth on the open range lasting much longer than 10 minutes meant that the mare

was having difficulty. Tyler (1972) observed a pony birth that was completed within 25 minutes from the time the mare lay down. Appaloosa mares generally gave birth while lying in an upright position with the forelegs stretched out in front and the body weight resting on the sternum (Blakeslee, 1974). New Forest ponies delivered while lying fully recumbent (Tyler, 1972).

Blakeslee (1974) stated that appaloosa mares showed no preference for a birth site other than to tend to avoid the night grazing area because most mares foaled at night. Birth sites with respect to vegetation or topography were not determined because all observed births were on the winter range which was flat to rolling, and the surrounding vegetation similar. She also reported that appaloosa mares almost without exception isolated themselves before giving birth, and the dominant mares went greater distances from the group than the subordinate mares. Feist (1971) did not observe any births within the Pryor Mountain herd but did find foal skeletons in secluded areas. Tyler (1972) reported that pony mares chose a variety of birth sites, sometimes secluded, sometimes near their group companions or close to busy roads. Dobie (1952) and Ryden (1971) stated that the only time wild stallions permit a mare to leave the group is when she is about to foal.

Dominant appaloosa mares spent longer times at the birth site and did not rejoin their family groups with their foals as soon as subordinate mares. Mares in their last month of pregnancy or geldings sometimes adopted the foals of primiparous or subordinate mares. When this occurred the foal, being unable to nurse, usually died. Some parturient mares permit another mare to accompany and remain near them at the birth site. This associate is nearly always a mare without a foal of her own (Blakeslee, 1974).

Reaction of other horses to mating. Tyler (1972) observed yearlings, foals and sometimes dominant pony mares attempt to prevent mating by either kicking at the stud or estrous mare or by placing themselves between the mare and stud. Feist (1971) observed other mares kicking at both the estrous mare and stud, and Blakeslee (1974) observed other mares kicking at the stud. Neither writer reported interference by foals or yearlings.

Food Habits

Probably the most important change that occurred in horse evolution was the transition from a browsing to a grazing animal. The teeth of early horses were efficient for eating a large variety of foods as long as the food was soft and did not wear down the teeth too rapidly. Early horses could not have lived on grass even if it were available because it would have

worn out their teeth at an early age. As grasses became more abundant (determined from fossil grass seeds) many browsing animals unable to adapt, disappeared. The horse exploited this change by evolving teeth that permitted them to change from browsing to grazing. The present tooth pattern of equids developed during the Miocene and has not changed greatly since that time. After the new type of dentition was developed, horses could eat most any vegetable matter including harsh prairie grasses. Three main changes occurred: tooth patterns changed to permit grinding, crown height increased to give longer life to the teeth, and a cementum layer developed. The cement filled the valleys and pits in the teeth and prevented food from lodging and decaying; it also prevented the brittle enamel crests of the teeth from breaking. The tooth system of the present-day horse is highly specialized for eating grass which, due to its high silica content, is a very harsh food. As a result, the teeth of horses wear down rapidly. As they wear, the teeth in the upper jaw move down and those in the lower jaw move up so that a grinding surface is maintained at the same level. When the teeth are worn to the roots and can no longer grind, the horse will starve. Generally, however, most wild horses die of other causes before this occurs (Simpson, 1951).

As the teeth of horses changed, undoubtedly digestive adaptations also occurred, but since fossil records leave no evidence this cannot be substantiated (Simpson, 1951).

Although the horse is a grazer he can eat and apparently survive on a wide variety of foods. In various parts of the world horses are fed grapevines, leaves of lime, lawn clippings, garden refuse, garbage, bamboo leaves, and even dried fish (Ensminger, 1951).

The digestive tract of the horse is smaller than that of a ruminant and is not able to handle as much roughage. However, since bacterial action similar to that in a ruminant takes place in the caecum and colon, the horse does not need high quality protein in its diet. This is not true of young colts, however, since much less bacterial synthesis takes place (Ensminger, 1951).

The esophageal and intestinal opening of the horse are close together, thus water passes quickly through the stomach and small intestine. No food leaves the horse's stomach until it is about two thirds full. As the horse eats, partially digested food passes out into the small intestine in a continuous stream--as a result, up to three times the capacity of the stomach may pass out during a large meal. Emptying of the stomach slows only when eating stops, and the stomach is never empty unless the horse has not eaten for several days. Some of the digested food is absorbed by the stomach but most absorption takes place

in the intestines. Within the small intestine the food remains quite fluid and passes through rapidly.

The large intestine is divided into five components: the caecum, large colon, small colon, rectum, and anus. Some bacterial action and synthesis of vitamins takes place in the caecum, but the greater part of digestion, including bacterial action and absorption of nutrients, occurs within the large colon (Hanauer, 1973).

The efficiency of the extraction of protein from foods of various composition is similar for cattle and horses (Glover and Duthie, 1958). There are important differences, however, in the mechanism of digestion between horses and ruminants. The ruminant maximizes the use of protein at the expense of energy. The mechanical and chemical breakdown of plant cells within the rumen is so thorough that relatively complete extraction of the cell contents takes place. This process of recycling for efficiency limits the passage of food through the digestive tract. When the ingested food contains large quantities of lignified cell walls the rate of passage is slowed and the overall assimilation of protein may be quite low. Under these conditions the animal may not be able to meet its maintenance requirements unless it has the opportunity to selectively graze components of the vegetation that contain cells with thin walls and a high concentration of protein.

In the horse, fermentation of cellulose occurs in the colon and large intestine, but the simple stomach remains the principal site of protein extraction. The slow process of cell breakdown that occurs in the ruminant is avoided and proteins are quickly assimilated as amino acids. The horse achieves almost equal efficiency with the ruminant in protein extraction through quantity rather than quality. Food passes through its digestive system almost twice as fast as it does in a cow; therefore, the horse can support itself on forage too low in protein to support a cow or other large ruminant, but it must maintain a much higher rate of intake (Bell, 1970, 1971).

In general the smaller the animal the higher is its metabolic rate. However, there is a degree of overlap between ruminants and non-ruminants from the effect of body size on metabolic rate. For relative maintenance (per unit weight per unit time) small animals need more protein and energy than large animals. They will lose weight more rapidly and be less competitive than a larger animal if they are both on a submaintenance diet. The reverse is true for an absolute maintenance (per animal per unit time) diet. With equal quality of food intake the smaller animal needs less food and as a result has more time to eat enough for maintenance. The smaller animal can thus afford to be more selective in its grazing habits and survive on a

sparse food supply that would starve the larger animal (Bell, 1970, 1971).

The year-round food habits of present-day wild horses have never been extensively studied. In some areas where these animals still survive, their habitat includes rough terrain, sparse vegetation and adverse climate. It is possible that the food habits of these animals are considerably different from the animals that live in less harsh environments.

Hansen (1975, personal communication) reports that he has been unable to find a single scientific publication on the diet of the domestic or wild horse on pasture or rangeland. His studies indicate that, under ordinary range conditions, 80 to 95% of the diet (on a dry-weight basis) of wild horses consists of grasses and grasslike plants and that they consume more browse than they do forbs. Appendix 6 lists some of the plants Hansen has found to be common in wild horse diets in the western states.

Captured wild horses of both Asia and America do not readily change their dietary habits to include concentrated feeds as do their domestic counterparts (Hafez et al, 1962).

Dobie (1952) wrote that captured wild horses preferred cottonwood bark to grain and that they were very adept at pawing through snow for their food. Hall (1972) made random feeding site observations during 1968 and 1969 on the Pryor Mountain herd. The major food item during spring, summer and fall consisted of grasses. During the winter they utilized brushy species, primarily saltbush (Atriplex spp.), rabbitbush (Chrysothamnus spp.) and big sagebrush (Artemisia tridentata), along with any remaining grass.

In Britain, Tyler (1972) conducted behavioral studies on the semi-wild herds of New Forest ponies. The herds are annually harvested for the sale of certain animals, primarily yearlings and foals, and the numbers of stallions are controlled. Other than this they lead a wild existence, remain free and forage for themselves throughout the year.

Their habitat consisted of deciduous woodland, heathland, grassland, valley bogs, and open water in ponds, ditches and streams.

The bulk of the ponies' food during the summer was purple moor grass, Molinia caerulea, along with small amounts of Agrostis, Festuca, Lolium and Cynosurus spp. Certain animals spent much time wading in ponds grazing Glyceria spp., Carex spp. and most small flowering plants. Bracken (Pteridium aquilinum) was the only other food plant eaten in quantity. Between autumn and

spring, leaves and shoots of brambles (Rubus spp.), oak (Quercus robar) and beech (Fagus sylvatica) were eaten.

The normal daily pattern of the ponies was completely disrupted when acorns were abundant as they spent most of the day foraging for these. In 1964 the deaths of 42 ponies were attributed to poisoning from eating acorns. When snow was on the ground leaves of holly (Ilex aquifolium) and gorse (Ulex europaeus) provided almost the only food. These plants were grazed as high as the animals could reach (approximately 8 feet).

The author reported that when hay was fed during the winter there were a few groups of ponies that never approached the hay piles and apparently did not recognize it as food.

Feist (1971) spoke only qualitatively on feeding habits of the Pryor Mountain herd. Grass was preferred but in short supply so that the animals were forced to supplement their diet with other types of vegetation. Where water was abundant they ate marsh grasses, weeds and forbs. Among woody plants, he observed horses grazing the new growth of saltbush, greasewood (Sarcobatus vermiculatus), black sage brush (Artemisia nova) and on rare occasions Utah juniper (Juniperus osteosperma) and mountain mahogany (Cercocarpus spp.). He noted horses pawing up and eating the roots of winter fat (Eurotia lanata) and two species of milkvetch (Astragalus kentrophyta and A. gilviflorus). He also reported sighting a mature, an immature and a yearling female eating old feces from a stud pile during the summer months.

Appaloosa horses grazed for 1½ to 3 hours before resting, and on the summer range they spent much less time grazing during the day than they did on the winter range. They were observed grazing practically all species of grass plus elk thistle (Cirsium spp.) and lichens and bark from quaking aspen (Populus tremuloides). Although sagebrush, shrubby cinquefoil (Potentilla fruticosa L.) and prickly pear cactus (Opuntia polycantha Haw.) were abundant they were never observed eating these species (Blakeslee, 1974).

When short of grass, domestic horses will eat leaves of trees and shrubs and peel bark from young trees (Smythe, 1966).

Colostrum, the milk secreted by the mare the first few days after partruition, is very important to the newborn foal. It is not only different in chemical composition from the mare's normal milk but contains antibodies to protect against certain infections, and it serves as a natural purgative (Ensminger, 1951).

Senses

Vision. The horse is color blind and sees the landscape ahead as a mosaic of various shades of gray caused by differently lighted areas. Its eyes are incapable of breaking up a visual image into individual items such as trees, grass, fences, etc. The horse recognizes movement through changes in brightness, tone, and the relationship of the moving subject to fixed objects. Any object that remains perfectly still may go unrecognized.

The eyes of the horse are set on the side of the head so that each eye receives a different scene. When the images are superimposed the horse views a flat panorama. The eye lens is non-elastic and the retina is arranged on a slope with the bottom of the retina nearer the lens than the top. Neither the cornea nor the lens of the horse's eye is truly shaped, thus horses suffer from astigmatism; they have trouble focusing on a subject a little way ahead and therefore often mistake a harmless object as something dangerous. To focus on objects at different distances the horse raises or lowers its head so that the correct part of the retina is on the subject. Although the horse possesses eye muscles to turn the eye in various directions, they are seldom used primarily because of the positions of the eye and the fact that the neck is long and moveable. Generous movement of the head is absolutely necessary if the horse is to focus its eyes properly. When grazing, the horse is able to view objects from every direction by moving its head. Objects to the rear can be seen between its legs. A horse sees most and farthest when it stands still with head erect and the forehead and muzzle perpendicular to the ground. In this position it can probably see all the landscape for several hundred yards around by alternate use of frontal and lateral vision. Horses move the head into position to look straight ahead and the ears point forward. When a horse is paying attention to objects on either side of the body it cannot see very well in front of the body; in like manner when it is staring straight ahead it cannot see what goes on on either side (Smythe, 1966).

Smell and taste. It is often difficult to disassociate taste from smell in horses. Some horses will accept a strong smell and refuse on taste, whereas others will reject strong smelling substances without tasting. Domestic horses have a liking for salt, sugar, and honey. They dislike most strongly aromatic substances such as peppermint, eucalyptus, thyme, and fats or anything of a meaty nature.

The true nostrils of the horse open into the nasal chamber which contains large turbinated bones that are very brittle and covered with mucous membranes. The nasal surfaces contain areas of

closely packed smell buds and olfactory nerve endings. They also have a false nostril which runs upward as a blind pouch. Horses are nose breathers with the nostril size varying considerably among individuals. They do not open their mouths or drop the tongue until completely exhausted (Smythe, 1966).

The muzzle of the horse is soft skinned, flexible and capable of receiving environmental stimuli. Sensory cells and nerve endings embedded in the connective tissues of the lips and nostrils plus the long bristling hairs that stick out in all directions are each capable of receiving sensory stimuli. The region of the lips and nose perform functions of the hand in man. The nose of the zebra is far more useful for orientation and warning against surprise attack than is the eye (Burkhardt et al, 1967).

The soft palate of the horse is large and somewhat pendulous. It is used to block the open end of the larynx to prevent choking when the horse is eating or drinking. It may also drop into the pharynx and limit mouth breathing when the horse is exhausted or nearly so.

Stallions have an acute sense of smell and can smell a mare in estrous at a considerable distance if she is upwind (Smythe, 1966).

The horse's ability to smell distant water has saved the lives of many early riders. Old time mustangers, when following a band of wild horses, were very careful not to change their clothing because their odor would change. Most horses can smell snakes, and there are reports of a horse that could track deer. South American horses gallop about in the dark and avoid the burrows of hundreds of Vizcacha (Lagidium spp.) holes, probably by smelling them (Dobie, 1952).

Domestic horses will eat a great variety of drugs one would expect them to refuse. They are apparently unable to discriminate between edible and poisonous plants and, being unable to vomit, they are unable to get rid of the poisonous ones (Hafez et al, 1969).

Hearing. Horses hear over a great range of frequencies and can pick up sounds too slight for human ears. They have the advantage of a long neck and concave ears that can be moved in any direction to not only detect sound but also to pinpoint the origin. There appears to be a connection between the ears and nose of the horse because when the ears prick the nostrils dilate. When a horse's ears are laid back on the neck it is either a sign of temper or an indication of stress such as running hard.

The pitch ranges of hearing in most domestic animals is known; however, horses are an exception. There has been little experimental work done on their hearing.

Horses communicate with each other and other animals with a number of vocalizations and sounds. Mares communicate to their foals with a wide variety of low-toned whinnies, each of which appear to convey a different meaning (Smythe, 1966). Dobie (1952) states that the scream of a stallion is one of the most terrifying sounds in nature and constitutes a warning to all other animals and stallions within hearing distance.

Domestic horses appreciate sounds from humans, and there are many stories of grooms who became famous by their abilities to calm frenzied horses by talking, whispering or hissing to them. Highly strung horses are often excited or alarmed by sounds that are unfamiliar such as escaping steam, fireworks, thunder, or even the rustling of paper.

Horses can sense very slight ground vibrations through their legs and feet. When grazing, these vibrations are felt through the limbs, teeth, jaws and bones of the head. The footsteps of a man can be picked up long before they become audible (Smythe, 1966). South American gaucho horses which lived in a semi-wild state expressed great fear of Indian attacks. They would often come running home when an imminent Indian attack was still a day's ride away. A few frontiersmen trained their horses to fear the odor of Indians (Dobie, 1952).

Tactile sensations. In order to maintain its normal body temperature of about 100.3° F., the horse sweats and shivers. It has the ability to sweat at a moment's notice from exertion, fear, or excitement. The muscular exertions expanded when working or running hard in such a large animal makes this a necessity. Sweat glands in the horse occur in the neck, certain parts of the back, the shoulders, axillae, and groin; however, there are no sweat glands in the skin of the limbs except between the hind thighs. Foam forms on the body and limbs after continued exertion when sweat pours from the suboriferous skin ducts, and there is a considerable amount of heat loss through water vapor from the breath.

The ability of the horse to fairly rattle his skin to dislodge insects or when rising from the ground to remove adhering particles from the skin is well known. This is made possible by the panniculus muscle which covers the greater part of the body beneath the skin. The same muscle is involved in shivering, which the horse uses to increase surface temperatures when it is cold.

Many horses respond very rapidly and often vigorously to skin stimuli; the neck and shoulders, the skin of the lower limbs especially around the feet and the coronets, the heel at the rear of the pastern, and the skin on the ribs and flanks are very sensitive. Most horses appreciate scratching on the skin of the withers and gentle patting of the neck and face (Smythe, 1966).

Horses have certain skin areas that are extremely sensitive to certain irritants, either vapor, solids or liquids. These include the lips and skin of the muzzle, the skin inside the elbows, groin, beneath the tail, the eyelids and their conjunctive areas, plus the skin surrounding the nasal openings (Hafez et al, 1969).

Social Organization and Behavior

General. Behavioral and social studies of truly wild horses are nonexistent, and it is only within the last decade or so that very limited attempts to study the wild horses of the American West has been attempted.

Some form of close aggregation of groups of individuals or "clumping" is common among herbivores. Animals aggregate for protection from predators, mating, and facility in feeding. However, according to Allee's principle, each species has an optimum aggregation value. Densities above or below this value tend to act as factors in population regulation (Boughey, 1968).

The social organization of wild horses is different than that of most ungulates. All wild horses belong to a harem or family group controlled by a dominant male, with the exception of adolescent males that have been ejected from the harem by the lead stallion, which form into small bachelor groups or bands. Any wild horse seen by itself is either an adolescent male, a male that has reached maturity and is trying to capture its own harem, or a crippled, diseased animal unable to keep up with the group. Hall (1975) states that a lone animal normally is an old stud that has lost his harem. He never observed one of these older animals in a bachelor group.

Each harem also contains a top-ranking mare that governs daily activity. She leads the group to forage and water and is second to the stallion in command. Whenever the group runs to escape danger this mare takes the lead with the stallion bringing up the rear (Dobie, 1952; Ryden, 1970). Hall (1972) reported during the 1971 roundup of the Pryor Mountain horse herd that when a band was harassed, the lead stallion was the first to go off by himself. This was observed repeatedly. He also commented that the instinct to follow in wild horses was very strong. When

a band lost its lead mare the remaining horses were often completely disoriented.

The stallion's functions are to breed, keep the group intact, prevent social strife, defend against other males of the same species, and defend against any danger that threatens the family group (Dobie, 1952; Ryden, 1970). Hall (1975) doubts that the stallion will defend against any danger threatening the group other than that posed by a competing stallion.

The protection and defense of a family group or harem by any animal has three main functions. It distributes the animals over the available environment, provides for the selection of the strongest male by fighting (which affects the progeny), and offers defense for the young (Lorenz, 1963).

Stallions control their groups by biting, kicking, and by a threatening posture that includes elongating and arching the neck and weaving the head back and forth. This threatening posture is generally all that is necessary to make any member of the group obey (Ryden, 1970).

Klingel (1972) states that a number of behavioral patterns are almost identical in the Equidae. In their social organization, however, there are considerable differences; two basic patterns exist. The plains zebra (E. quagga), the mountain zebra (E. zebra), the horse (E. przewalski) and possibly the asiatic wild ass (E. hemionus) live in harem groups composed of one to several mares led by a dominant stallion. Surplus stallions form groups of their own. The young leave the family group in a set pattern, and do not establish territories. These social units move freely over their home ranges which they share peacefully with conspecifics. In opposition to this type of social behavior, Grevy's zebra (E. grevyi) and the wild ass (E. africanus) display no personal attachments between any individuals other than mare-foal relationships. The animals often occur singly, in stallion groups, mare groups, mare-foal groups and mixed herds. The groups are variable and their composition may change at any time. Some of the stallions are territorial but do not prevent conspecifics from entering their territory as long as they do not interfere with the mating activities of the territorial stallion. They only defend territories when there is an estrous mare near the boundary. Only the territorial male will court a mare at any one time because all the other males are subordinate to him. There is no order of dominance or leadership among adults. All adult individuals seem to be of equally low rank and only the mare and her foal ever search for each other when they are separated.

Aggressiveness. Individual aggressiveness in vertebrates towards members of the same species is expressed in two ways:

defense of a given territory and the establishment of hierarchies of precedence within social groups (Collias, 1970).

Due to the potential danger, most mammals avoid fighting if possible. They generally resort first to aggressive display and threats which often result in submission or appeasement by the weaker opponent. Fighting seldom results in the death of the loser unless the environment is overcrowded. An unsound environment distorts the normal patterns of social behavior (Scott, 1958). There are many examples of increased aggression in crowded populations (Mathews, 1964). Crowding may also produce a reverse reaction when it exceeds certain levels, and animals may become passive and nonreactive (Southwick, 1970).

When wild horses reached their peak numbers during the last century they often existed in crowded environments (Dobie, 1952). In the Pryor Mountains, Hall (1972) reports that they still do, which may account for the sometimes conflicting reports on behavioral patterns at different times and places among wild horse bands.

Many stallions are very domineering and keep close watch over members of their group. Only during foaling will the stud permit a mare to leave the band so that she can find a secluded spot to foal (Dobie, 1952; Ryden, 1970). Hall (1972) reported that some mares appeared to be fickle and were observed away from their group for several days at a time. He also observed extreme variation in the amount of time mares remained away from the group during foaling (one day to several weeks). He attributed this variation to the strength of her bonds with the group.

If a mare with foal falls behind during an escape attempt the stud may kill the foal by breaking its neck or he may force the mare to abandon it. Studs also may often display threatening gestures toward humans while the band is escaping. If another stallion approaches the harem, the two stallions posture with tails arched and heads pressed together staring at each other until one backs down. If a fight ensues, they rear on their hind legs, ears back and mouth agape. They strike with their forefeet, bite for the jugular and often wheel and kick. During the encounter they shriek, snort and scream. If one falls he is stomped by the other. The winning stud seldom chases his rival for more than a short distance (Dobie, 1952; Hall, 1972; Ryden, 1970).

The intolerance for other males is greater during the breeding season than it is at other times and reaches its lowest ebb during the winter months (Hall, 1972).

All age classes of appaloosas threaten foals, but adult mares are more aggressive toward foals not their own than are other

age groups (Blakeslee, 1974). All pony mares were aggressive to strange foals and either threatened, kicked or bit them if they came close (Tyler, 1972). Feist (1971) did not find any consistent pattern of dominant hierarchy among the individual mares of the various bands in the Pryor Mountain horses. Exhibition of authority by one mare over another appeared to depend on a particular situation and the superior dominance of the stud overshadowed any formation of hierarchy among the mares. Hall (1972), who spent a great deal more time with these horses than Feist, reported a definite recognizable hierarchy within each band and that, once established, it remained fairly constant. Blakeslee (1974) stated that, among adult females, neither age, size, weight, nor length of time in the group determined dominance. The only observed characteristic common to dominant mares was their tendency to be aggressive. Tyler (1972) noted kicking fights between pony mares on several occasions, presumably to establish or maintain dominance. The rank order of mares, once established, was very stable and a mare dominant over another mare in one situation was never subordinate to the same mare in another situation. It was also noted that a subordinate mare rarely challenged a previously established more dominant mare. The length of time a mare lived in a group was not important in determining rank, and a foal shared status with its mother only when it was close to her. The rank order of mares in any one group or where several groups were considered was a simple linear one, but with large numbers the order was complicated by triangular relationships within the hierarchy. In one group of eight dominant mares there was a significant correlation between their size and rank. However, this did not hold true with other groups and neither size nor age explained the high position of some mares in hierarchies.

Dominance between stallions and mares varied. Stallions always dominated where food was concerned but not in all other situations.

Family groups. The number of mares, yearlings and colts controlled by a stallion varies. Dobie (1952) reports viewing as many as a hundred horses in a group but adds that 15 to 20 was the usual size. Other reports state that normal groups consist of one to eight mares exclusive of colts and yearlings (Hoyt, 1886). Wild horse bands in the Pryor Mountains and in Nevada averaged three to four animals composed of a stallion, lead mare, subordinate mares, yearlings, or colts (Hall, 1972; Pellegrini, 1971). When wild horses are frightened or stampede, the bands may join together into one large herd controlled by a single stallion. However, the large bands again separate into individual harems when they stop running (Dobie, 1952; Ryden, 1970).

Stallion colts are usually ejected from the band at an early age, about two to four years. The age at which they are expelled seems to depend on the aggressiveness of the dominant stallion. These young males may remain alone near where they were born until they can join up with a bachelor group. If they join together they are controlled by a dominant stallion in a loosely organized group. Early writers reported as many as 25 of these young males in a band. Later reports indicate two to five animals varying from two to five years of age. When stallions approach the age and size at which they can capture a harem of their own they may leave the group and remain alone (Dobie, 1952; Hall, 1972; Ryden, 1970).

Hall (1972, 1975) stated that there was often a considerable interchange of animals between harems. Many such interchanges were observed in the Pryor Mountain study. He relates the interchanges and the small band size to the sex ratio (60% males, 40% females), and to overcrowding. He reported that in some areas in Utah the band size averages six animals. In these cases the sex ratio is about equal and there is no evidence of overcrowding.

Klingel (1965) reported that family groups among the plains zebra (Equus quagga) are extremely stable and are not held together by the dominant stallion. In five observed cases where the lead stallion disappeared, the groups remained together until subsequently taken over by another stallion.

Sometimes large harems have two stallions; both may breed, but one is always dominant. When the herd is in flight this second stallion runs abreast and forward of the male in command (Dobie, 1952; Hall, 1972; Ryden, 1972).

Home range. In any discussion of home ranges or territories of America's wild horses it is well to remember that these two items may be those imposed or strongly influenced by man. Field studies that will enable us to understand the diversity of ways these animals use the space available to them are virtually nonexistent.

Every species of mammal has a home range of some type. These home ranges may be stationary or they may change with conditions. The ranges often overlap and migratory animals may have more than one home range. A home range may be defined as the area over which an animal or a group of animals travel in pursuit of routine activity. It may have no clearly defined boundaries but it must produce the energy requirements of the specific group of animals that occupy it. It implies a self-imposed restriction of movement (Burt, 1943).

Estes (1974) claims that the actions of zebras are found in all members of the horse family; therefore, the only truly wild member of the Equidae that may furnish clues as to how wild horses once lived is the plains or Burchell's zebra (Equus Burchelli). There are still over a half million of these animals on the savannah of northern South Africa and the southern Sudan. During their annual migrations herds of zebras may stretch across the grasslands as far as one can see.

Plains zebras live in stable families, or harems, of mares and foals, with each family of six to sixteen members controlled and defended (mostly from other males) by one stallion. Large troops of zebras are made up of these units plus bachelor herds which mainly consist of immature stallions.

Both Feist (1971) and Hall (1972) reported on home ranges within the Pryor Mountain herd. Hall observed that the ranges varied seasonally with an individual band using as many as five areas. He observed at least 17 bands of horses using the same area at least part of the time. These actions were attributed to congestion and lack of adequate forage. Feist reported that home ranges were relatively well defined and adhered to and only rarely did a band leave their home range. Pellegrini (1970) reported that the home range of the three bands most extensively studied in the Wassuk Range of Nevada confined their activity to cube-shaped areas, while the home range of lone horses was linear along the boundaries of two adjacent home ranges. Among the New Forest ponies, home range depended on the topography and the nature of the habitat. Four requirements for a home range were necessary: grazing area, shelter, water and shade. When these were close together the home ranges were often small (200 acres). The home ranges of the different groups were very stable and though they were often almost identical or overlapped, each group tended to use a different part of the grazing area (Tyler, 1972).

When the wild horses were at their peak during the last century many writers reported large herds. Early maps of Texas marked the territory between the Rio Grande and Nueces Rivers as "vast herds of wild horses." A Franciscan missionary reported that when crossing an area uninhabited by people the wild horses were so abundant that their trails made the area look like the most populated in the world and that all the grass was gone. Within these large herds, however, the individual bands or harem groups retained their identity (Dobie, 1952).

Lorenz (1963) lists several species of animals (bison, antelope, and horses) which do not maintain strict home ranges or display territorial jealousy if there is enough food for all.

Indians depended on the home range instinct to hold their semi-wild herds on reservation lands, but not all horses reveal this trait and as a result many of them reverted to a wild state (Ryden, 1970).

Mustangs confine their feeding and flights from danger to certain boundary lines. This fact was well known to plainsmen who made a business of catching wild horses (Cook, 1919).

Smith (1841) stated that the genuine wild horse is migratory, moving north in the summer and returning in early fall. The mixed races (feral horses) move to pastures rather than to points of the compass.

Territoriality. A territory in animal populations may be defined as that part of the home range which is protected from individuals of the same species either by fighting or by other aggressive action. Territoriality is so widespread among the vertebrates and in many of the invertebrates that it must be considered a basic animal characteristic. Although it is not found in all animals nor is it always developed within strict boundaries among the animals that possess it, the potential is there whether the animal displays the characteristic or not (Burt, 1943).

There is only scant evidence to indicate the degree of territoriality displayed by wild horses.

Pellegrini (1971), in his study of Nevada herds, concluded that wild horses establish a territory even though no special section of the home range exists as a defended area. Hall (1972) reports that horses in the Pryor Mountains do not establish territories, and he is convinced that they are not territorial. The individual bands maintain a "sphere of intolerance," an area near the harem or family group in which the dominant male will defend against other males. This "sphere" (the distance within which another stallion may approach the harem) expands during the breeding season and contracts after it is over. During the winter months it may be almost nonexistent.

Feist (1971), reporting on the same herd of horses, concluded that the bands or studs do not exhibit territorial behavior. They do, however, maintain a spacing between bands. In all observations this spacing was related to distance between bands and never to the defense of a ground area.

The dominant males of the plains zebra do not defend a territory. They control moveable property rather than real estate (Estes, 1974).

Vocalizations. Waring (1971) states that social interactions are common among both feral and domestic horses. These interactions occur through visual, auditory, olfactory, gustatory and tactile cues. He warns against using any single means of communication out of context. To fully understand the importance of sounds, all other means of communication must be identified and understood.

Using American Saddle Bred horses as subjects, he tape recorded their vocalizations, then by spectrographic patterns he divided them into seven basic categories. Identified were squeals, nickers, whinnies, groans, blows, snorts, and snores--the first four vocal, the latter three non-vocal. Breed variability may exist, but it probably falls within the basic sound categories described.

Squeals: express threats. Nickers: anticipatory sounds prior to being fed; stallions in courtship; and by mares when foals are in jeopardy. Whinnies: uttered during distress or inquiry. Groans: issued during discomfort or anguish. Blows: express alarm or aid olfactory investigation. Snorts: used in conflict situations--they may express relief or disgust. Snores: produced during inhalation, two types were detected--one of short duration uttered prior to emitting an alarm blow, the second, of longer duration, produced while the animal was prone. The author indicates that all of these sounds are used by either sex.

Feist (1971) identified four definite vocalizations in the Pryor Mountain herd: the snort, neigh, nicker, and scream. He observed the snort as a danger signal used mostly by stallions, seldom by mares. The neigh was used as a distress call primarily by mares and younger horses of either sex. Studs used the neigh to call animals that had strayed or when they were in a build-up to a fight. The nicker was used in closed communication and courtship. The scream was emitted exclusively by studs during fights.

Hafez et al (1962) identifies the snort as a danger signal, the neigh or whinny as a distress call, and the nicker as a sign of relief or for closed communication and courtship.

Tyler (1972) reported that the squeal was most commonly uttered by mares when a stallion approached and sniffed them. Mares also squealed when fighting or when displaying aggressiveness. Stallions only occasionally squealed when fighting.

Postures and facial expressions. Tyler (1972) states that six expressions are recognized in equids but they are not all seen in true horses. She describes five of these expressions among the New Forest semi-wild ponies.

Ponies yawned by holding their mouths wide open with the upper and lower teeth exposed and ears forward. Yawning occurred before or after resting, when mares in estrous were being sniffed by stallions, in stallions after copulating, and in foals after suckling.

The greeting expression occurred when two group companions or a stallion and a mare met; they sometimes extended their heads and touched each other's muzzle and lips. These often developed into threat postures when the ponies laid back their ears. The greeting expression was also used as a preliminary to mutual grooming.

During the flehmen posture the animal extends its neck and curls the upper lip so that the teeth are exposed. Schneider (1930, 1931, 1932a, b) described the flehmen in a wide variety of ungulates. Hafez et al (1969) states that this expression commonly takes place during the precopulatory patterns of many ungulates. Estes (1974) states that during the flehmen, urinary odors are apparently assayed in an accessory olfactory system specialized to detect concentrations of sex hormones. In the New Forest ponies (Tyler, 1972) the expression was always observed as a reaction to some smell: by stallions after sniffing a mare; by stallions, mares or foals after sniffing urine; by mares or other ponies after sniffing fresh placentae or by any pony at the sight of another showing the flehmen posture. Blakeslee (1974) stated that the flehmen posture was exhibited by foals, yearlings, and adults in a variety of situations other than smelling urine on the ground. The posture was induced by touching the nose of a horse with a human hand and by sight of another horse urinating, or by the sight of another horse exhibiting the flehmen posture. Feist (1971) observed 55 situations of this action in the Pryor Mountain herd. All of them were related to olfactory responses and all of them were by males.

The threat expression is characterized by backward-directed ears and was first described by Antonius (1937). Tyler states that it is absent in asses, half-asses, and Grevy's zebra (Equus grevyi). The true horses do not draw up the corners of the mouth as do the other species of zebra. In the New Forest ponies mild threats were exhibited by slightly laying back the ears, but intense threats were expressed with the ears flat back and sometimes the mouth slightly open, and occurred just before a dominant pony attempted to bite a subordinate pony. Stallions also used the threat gesture when driving mares by stretching the neck toward the ground, ears flat, and swaying the head back and forth. Ryden (1970) observed similar actions when stallions threatened or drove mares.

Zeeb (1959) described the snapping expression. It is characterized by stretching of the neck with the ears slightly back and down, the corners of the mouth drawn back partly exposing the teeth, and the lower jaw in motion up and down. Tyler (1972) stated that the expression was common in the New Forest ponies when foals or yearlings were threatened or approached by adult mares or stallions. It occurred in a variety of occasions, most of which seemed to be released by fear. Occasionally it was a response of foals and even yearlings to approaching cows. Although it was regarded as a submissive expression it had no effect in preventing older animals from carrying out their threats. Foals and yearlings were often bit or kicked by mares even after they had made the snapping response. Feist (1971) recorded 21 instances of this behavior by young males to the dominant stallion. Ordinarily the stallion made no recognition of the submissive behavior.

Grooming. Domestic horses, unlike cattle, do not groom each other but they may nibble each other along the withers or stand head to tail and flick flies off each other's faces. Nibbling of the withers is usually a sign of recognition and often may be noted when two animals meet after an interval (Hafez et al, 1969).

Trumler (1958) classified grooming in zebras as follows: localized muscle contractions; shaking; striking one part of the body against another or against the ground; rubbing (includes rolling); scratching; nibbling; and social or mutual grooming. Feist (1971) stated that mutual grooming was a common part of the daily activities in the Pryor Mountain wild herd, accomplished by pulling the lips back and using the incisor teeth to groom the neck, withers, base of the mane and on down to the rump. Horses also groomed one side, then switched to groom the other side. Mutual grooming occurred only between herd members and almost all grooming combinations were observed except between the stud and immature males. Tyler (1972) observed all the above forms of grooming in the semi-wild New Forest ponies. Mutual grooming was a response to insect infestations, shedding of hair, or as a means of social contact. Each pony had only a small number of partners with which it groomed. These partners were usually related, unrelated group companions, or members of two closely associated groups. The usual grooming partner of a foal was its mother, another sibling or another foal. Mutual grooming bouts were most often initiated by the subordinate animal and ended by the dominant animal. Mutual grooming was a common activity among all age classes of appaloosas. All observations of grooming were within their particular group, and there was no consistent pattern of preference for certain partners (Blakeslee, 1974).

Feist (1971) observed 81 cases of rolling, 50 of which were in dust and 31 in mud and water. Although yearlings and foals rolled, no female yearlings or foals were observed rolling in dust or mud. Dusting sites were scattered throughout the range and were used by all bands or horses that passed by. Ponies usually rubbed against fixed objects such as stumps, trees or wooden bridges. When insects were abundant they spent long periods stamping, kicking at their bellies, shaking and lashing their tails or rolling. Rolling often occurred at the end of a resting period or when they encountered wet grass after a rain, patches of bare ground or sawdust. No special sites were reserved for rolling (Tyler, 1972). Appaloosa horses choose specific pieces of ground for rolling places, and these were so well used that they were denuded of vegetation and covered with dust. Rolling in water was common for all age classes as was rubbing against trees or other fixed objects (Blakeslee, 1974).

Play. The word play is a human concept applied to any activity other than work. The term is difficult to apply to wild animal activity or behavior; since animals do not work (in the human sense of the word) they cannot be said to play.

Human play no longer has survival value; however, in animals it must be assumed that it does have value. Play occurs among animals only when they are free of environmental or physiological stresses. It is a widely held view that play is preparation for adult activity, and the animals that have an opportunity to play prior to becoming adults have a selective advantage over those animals that are denied this opportunity. However, it has never been clearly shown that animals prevented from playing are less efficient as adults than those that play (Loizos, 1966). Play increases locomotive skills and may be used to test social dominance (Hafez et al, 1969).

Feist (1971) reported that play among foals of the same band and foals of other bands occurred regularly. This was tolerated by the studs if the juveniles returned to their own bands after playing. Play involved running, kicking, sudden stops and starts, and head tossing. Foals were observed playing at all times of the day but primarily in early evening when temperatures had cooled. Play among other age groups was rare and if started was quickly ended by the dominant male. Tyler (1972) reported that play in young foals took the form of the foal galloping to and from its mother or making irregular circles around her. It bucked and kicked as it galloped. Sometimes the foal reared up at its mother or pulled at her mane and neck. Young foals were very inquisitive and often sniffed or nibbled at strange objects and then rushed back to their mother. Play between foals did not occur before their second

or third week. After this period, play between foals became more common. Foals nibbled, groomed, or chased one another and kicked out with their hind legs and bucked or reared as they galloped. The play of colts older than four weeks differed from that of fillies. Colts spent long periods play fighting, rearing, pawing and attempting to bite. Most play fights between colts contained all the components of true fighting between adults. Play between fillies which often ended as mutual grooming was much less common than play between colts or between colts and fillies. Both colt and filly foals showed interest in stallions and often attempted to approach them. Most stallions were very tolerant and usually ignored the foals. Play fights were observed between stallions and colts but never between stallions and colts over two years old. Blakeslee (1974) observed similar play among foals but did not report any differences between the play of males and females.

Sleep and rest. In lying down the horse brings all of its legs under the body, bends its knees and hocks and permits the chest to touch the ground before the hind quarters. When down, the horse either rests on one side of its chest with a fore and hind leg underneath or it lies on its side with all legs stretched out. In getting up, the forelegs are stretched out first followed by the rear legs pushing up the hindquarters. The horse may sleep very soundly for seven hours out of twenty-four, mostly during the heat of the day. Horses sleep standing up or laying down; however, it is rare to see all horses in a group laying down at the same time; one is always alert (Hafez et al, 1969). Many horses sleep on their feet and some graze all night (Ensminger, 1951). Ruckebusch et al (1970) studied behavior and physiological responses of horses during sleep. They state that sleeping while standing was rare in experimental animals but appeared to be frequent in animals maladjusted or insecure in their surroundings. Dobie (1952) wrote that wild horses never lie down altogether, many sleep on their feet and lay down only to roll. He relates the story of an old-time horseman who told him that wild horses napped regularly three times during the night, at about nine, eleven and just before dawn. Feist (1971) observed a number of situations in which horses rested or were sleeping. Foals spent a great deal of time sleeping while lying down; this decreased as they grew older. Mature animals only occasionally lay down and no observations were made of an entire band lying down. Yawning and stretching often occurred following sleep or rest. Pellegrini (1971) stated that horses in the Wassuk range of Nevada travelled little during the night. They either stayed near water or in sheltered areas, apparently sleeping most of the time. They also rested or slept in shaded areas during the day. Both foals and adults spend more time resting during the winter than in the summer (Blakeslee, 1974; Tyler, 1972). The latter author attributed this difference to increased food availability during the summer.

Pawing. The original function of pawing was part of the horse's nutritive behavior and always occurred together with an olfactory investigation (Odberg, 1972).

Horses paw through snow to obtain grass or they may paw to remove undesirable objects (stones, cactus) that interfere with or block their efforts to reach desirable forage plants. Pawing was also used to search for water from dried waterways where it was common for early cowboys to find holes dug by horses as much as eight feet deep. Pawing is also their means of breaking ice to obtain water (Boone, 1933; Dobie, 1952; Odberg, 1972; Smythe, 1966).

Horses paw for various other reasons. They have often been observed sniffing and pawing the areas where they are about to roll. Pawing may occur during the threatening behavior when two males meet and they may also paw during courtship if thwarted in their attempts to mate. Pawing and sniffing often accompany investigation of stud piles. Foals sometimes paw when they are frustrated in their attempts to feed, and mares may paw before foaling. Domestic horses paw at the sight of unreachable food given by humans or while waiting for an action they feel or "know" is going to happen (before a race), or they may paw from boredom or nervousness when they are in their stable (Boone, 1933; Dobie, 1952; Odberg, 1972).

Eliminative behavior. Vigorous adult horses defecate 5 to 12 times, and urinate 7 to 11 times per day (Hafez et al, 1969). Tyler (1972) estimated frequency of elimination in the New Forest ponies. Adult mares defecated on an average of once in just over 2 hours and urinated once every 4 to 4½ hours. Foals urinated about once per hour in the first week or so, but this gradually dropped to the same frequency as adults when they were about a year old. Stallions frequently sniffed piles of feces and then defecated or less commonly urinated on the pile. Sometimes they did this several times in succession on different piles of feces.

Horses, unlike cattle, stop whatever they are doing to urinate or defecate. They maintain a characteristic stance according to sex when eliminating; and after elimination the stallion, but not the mare, smells the eliminative product (Hafez et al, 1969). Ponies stopped grazing to urinate but merely raised their tails and continued to graze while defecating (Tyler, 1972).

Feist (1971) believes that there is much more significance in the eliminative behavior of wild horses than there is in domestic horses. Particularly important is the action of the stud in relation to other horses in the band and to other

studs. The stud's urination behavior is directed to excrements of the mare, whereas his defecation behavior is used primarily for the stud pile. Feist further believes that this behavior is dominance-linked.

Blakeslee (1974) found no evidence of dominance display by appaloosa stallions connected with eliminative behavior nor did they accumulate stud piles like wild horses.

Scent or visual boundary marking. The fact that wild horses deposit their fecal matter in one place and thus create piles of manure commonly referred to as "stud piles" is well known. There is little evidence as to the exact purpose of this type of behavior. It may be a form of scent marking, visual boundary marking or both.

Dobie (1952) gives an account of the many early explorers, historians, and others who were amazed at the numerous piles of horse dung that lined the trails used by wild horses on both the South American pampas and on the western prairie. He states that a stallion's dung piles constitute a visual and olfactory notice to other stallions that he had been there.

Shenkel (1947) concluded that scent marking legitimizes the leader, marks his territory and aids in making new acquaintances. Lyall-Watson (1964) interprets scent marking differently, stating that scent marking aids the animal in maintaining familiarity with his environment and assures him that he is within his home range. This interpretation suggests that scent marking is not used as an aggressive display for territorial defense even though it would be effective in maintaining a territory. Pellegrini (1971) indicated that mares and colts also accumulate dung piles and that these piles probably served as boundary markers. Hall (1972) discounts the purpose of stud piles for marking territory because the Pryor Mountain horses are not territorial and the piles appeared to be randomly scattered. Feist (1971) agrees with Hall. "If five bands passed by a particular pile on a trail or on a feeding area in one day it would be rare if all of the studs did not defecate with accompanying posturing on that pile."

Zebra stallions mark only the feces of mares in estrous (Klingel, 1969, 1972). He suggested that scent marking in zebras is vestigial behavior and probably inherited from territorial ancestors. The same author later reported that the marking behavior of the non-territorial equids has no known function. Kleiman (1966) distinguished scent marking from true elimination by three factors, one of which was directional posture. Pony stallions, when marking, oriented their eliminative products toward other piles of feces. They often walked from one pile of feces to another stopping to eliminate on

several piles. Stallions usually defecated when marking; mares and foals more commonly urinated (Tyler, 1972). Both Feist (1971) and Tyler (1972) reported that the amount eliminated by stallions when marking was controlled and expelled in small quantities, compared with true elimination. Feist observed stallions stepping over a mare's excretion and urinating in a short but strong blast. Stallions were also observed defecating up to three times during a short period while fighting. Tyler noted that there was no evidence that marking had any effect on other stallions.

Water and watering behavior. There is no data available on the amount of water needed or consumed by wild horses under their various habitat conditions. (Ensminger (1951) states that the average domestic horse will consume about 12 gallons per day. Stoddart et al (1975) quotes from early research on domestic horses and lists 10-12 gallons per day.

Among wild horses Feist (1971) noted no consistent watering schedule by any band. Generally each band visited a water hole once a day except during very hot weather when they watered twice a day. Over most of the range, horses were always within four or five miles of a water hole. The time spent at water holes rarely exceeded 30 minutes. Pellegrini (1971) observed territorial behavior of wild horses in Nevada at water holes. When two bands arrived simultaneously one band was dominant. The less dominant band did not water until the other band had left the area. Hall (1972) states that in the cooler months horses trail a considerable distance to water but during the warm periods of late June, July, and August they concentrate on water. Frei (1975) states that wild horses in eastern Nevada will trail as far as 10 to 15 miles to water and seldom stay any closer to water than three miles. When temperatures reach their maximum (95^{o} F.) during the summer the horses water every other day. Actual drinking time generally does not exceed 3-4 minutes per horse, and they rarely remain near the water hole more than 5 minutes after drinking. Appaloosa horses rarely remained long at watering places, usually no longer than a half hour. Although the horses used well worn trails going to and from water, they had no set pattern for time of arrival. They trailed to water at a certain time for several days in succession and then changed their schedule (Blakeslee, 1974).

Charles Goodnight, a scout during the Civil War, told Dobie (1952) that wild horses, unless severely disturbed, did not graze more than five miles from water and that they watered at the same spot each day. During droughts wild horses of the South American pampas sometimes became so frantic that upon finding water they piled into it on top of each other, drowning and trampling to death large numbers (Dobie, 1952). Smith (1841)

reports similar behavior in South American wild horses during drought periods. The thirsty animals trampled each other so furiously that thousands of skeletons lined their watering places. He suggested that these actions were probably a means of population control.

Foal behavior. The following has been extracted from a paper by Waring (1970) who studied foal behavior in American Saddlebreds.

Within seconds of birth the foal raises its head and assumes a sternal position. By pawing and by motions of the head and neck the foal attempts to move away from the mare; this drags the hind legs free of the mare's vagina and eventually severs the umbilical cord.

Within 15 minutes the foal attempts to rise but often not until three-quarters of an hour has passed do the hind legs flex sufficiently to permit it to stand. The eyes, open at birth, show distinct binocular orientation by 25 minutes. The mare vocalizes to her foal within minutes after birth, and auditory orientation of the foal occurs within 45 minutes. The initial stance is unsteady and the foal shifts frequently to maintain its balance. Suckling motions have been observed within 55 minutes. Nursing depends partly on the mare's willingness to stand still or position herself so the foal can find her nipples. Some foals nurse soon after standing and some do not succeed until almost 2 hours old. Defecation may occur prior to one hour of age and urination a few hours later.

At one hour of age the foal commonly shows ability in standing and moving about, can see and hear, can eliminate, express curiosity and care-seeking behavior. During the second hour the colt perfects its walking and shows evidence of its attachment to its mother; the mare and colt may vocally respond to each other's sounds. Sleep begins as short naps and increases until it occupies much of the foal's early life. Fear of new objects begins. When it is two hours old, the foal may walk easily, lie down, nurse, follow its mother, vocalize, seek shelter beside her, express fear, and sleep.

By half a day it can walk, trot, gallop, combat insects (by use of its tail or by kicking and nipping), urinate in a manner characteristic of its sex, exhibit short periods of animated play, and consume small amounts of forage. The mare-to-foal bond begins soon after birth and is stronger than the reciprocal. When the two are separated, the mare may show extreme excitement, but the foal exhibits disorientation more than distress.

Tyler (1972) observed foal behavior of the semi-wild ponies. Almost immediately after birth an observed foal had pushed its muzzle and a foreleg through the amniotic membranes. Within five minutes it attempted to stand, but this was thwarted by the mare's vigorous licking action. It stood within 33 minutes and suckled successfully 52 minutes after birth. Most mares began to lick their foals a few minutes after birth and continued to do so for as long as a half hour. On the foals' first day the mares are very possessive and keep the foals away from all other ponies. On the second day the foals are usually able to recognize their mothers by smell, and the mares become less protective. A few foals ate or nibbled at grass on their first day, and some were observed in such activities as rubbing, rolling, scratching, stamping, shaking and nibbling. They also yawned and displayed the flehmen posture and snapping expression. First-week foals seldom strayed more than 25 yards from their mothers and even those up to 5 months old spent less than 10% of their time more than 50 yards away from her. When a foal approached its mother to suckle, it often nickered, laid back its ears and tossed its head. The foal then moved in front of the mother pushing under her head before it attempted to suckle. It did this regardless of the direction of approach. The close relationship between the mare and her yearling continued even though the mare had a new colt. The yearling rested near its mother, groomed with her and followed her. Weaning usually occurred when foals were about a year old or at the time of the birth of a new foal. The author observed one pony mare which allowed her yearling to nurse after the birth of her foal, but considered this behavior atypical. Blakeslee (1974) stated yearlings were not generally allowed to nurse after the birth of the new foal. However, if a mare did not foal, her yearling frequently continued to nurse.

Tyler (1972) reported that until their third or fourth month, pony foals, due to their short necks, straddled their forelegs to graze. The average amount of time spent grazing by foals increased from 3.5 minutes per hour the first week to 16.3 minutes per hour after the fourth month. Foals in their twelfth and thirteenth months spent a mean of 44.4 minutes per hour grazing.

The author also reported that after birth, licking of the fetal fluids by the mare from herself and the foal seemed to be very important. After a mare has licked her foal, she is able to discriminate between it and other foals, and a relationship between mother and young becomes established. The great attraction to the fetal fluids was shown by a pony mare whose colt fell into a ditch soon after birth. The foal was rescued and moved a few yards away from the mother, but the mare remained near the ditch and the placenta. When the colt was carried back to her she began to lick it and a normal relationship was established.

Blakeslee (1974) stated that foals pull at and mouth various plants when one or more days old; however, they do not swallow the plant material until their teeth have cut through the gums at about the fifth day. Grooming in foals did not occur until they were about a month old, and the initial bouts usually were with their mothers. Very young foals had trouble drinking from streams, and it took them several days to learn to properly spread their forelegs and retain their balance while drinking.

Coprophagy in foals. Tyler (1972) reported that coprophagy was common in pony foals up to three or four weeks old. The feces eaten almost always belonged to the foal's mother, but on two occasions a foal was observed eating its own feces. Blakeslee (1974) also reported young foals eating feces, usually their mothers'. Older foals did not eat feces. Hafez et al (1962) report that adult domestic horses reject the feces of their own kind but that foals eat a considerable amount of fresh feces of adult horses. They attribute this behavior to the need for proper bacterial flora for the foal's intestines.

Predation and Disease

Predation. As far as is known, there are no scientific studies of predation on wild horses. The mountain lion (Felis concolor) is the only large predator remaining within their habitat that is capable of killing an adult horse. It is possible that coyotes could kill foals if they were unprotected. Feral dogs, when hunting in packs, certainly have the capability to attack and kill horses, but whether they do or do not has never been reported.

The only natural enemies of horses are mountain lions and wolves. All horses are afraid of bears but even in California where grizzlies were once numerous, they killed few horses. Wolves sometimes attacked horses but they preferred buffalo and after these were gone they turned to cattle. The natural prey of the mountain lion is deer, but once they had tasted horsemeat (especially foal) it became one of their favorite foods (Dobie, 1952).

Young and Goldman (1946) cite instances of mountain lions preying on horses in Arizona, Colorado and New Mexico. Raising colts and even maintaining a herd of adult horses was impossible in some areas due to lion predation. Once lions came addicted to horse flesh they often abandoned all caution. The writers also note that mountain lions are exceptionally fond of burro meat.

Diseases, pests and parasites. Outbreaks of diseases or infestations by pests and parasites within a wild animal population are often important indicators of other problems. These

may be related to habitat, poor nutrition, overcrowding, competition, injury, harassment, or other reasons.

The more common afflictions of domestic horses, unless otherwise indicated, have been adapted from Ensminger (1951). It is possible that any one or more of the diseases could be present in or transmitted to wild horse herds. Symptoms, treatment and details are beyond the scope of this technical note.

Equine abortion: Causes may be grouped into four categories: those resulting from infection by Salmonella abortivoequina; those from streptococci infection which gains entrance through the genital tract; a virus or epizootic type which is highly contagious; and those abortions that occur from miscellaneous causes which cannot be classified into the above categories. These may vary from accidents or injuries to nutritional or endocrine disturbances.

Equine encephalomyelitis (sleeping sickness): a disease carried by 4 immunological, distinct filtrable viruses. It is vectored by 13 members of 3 genera of mosquitos of which Culex tarsalis is the most likely carrier. It may also be carried by spotted fever ticks (Dermacentor venustus) and assassin bugs (triatoma spp.).

Equine infectious anemia (swamp fever): a very serious blood disease of horses and mules. It is caused by a specific virus that may stay in the host for years. Treatment has been unsuccessful.

Infectious adenitis: Also referred to as strangles or distemper, the disease is caused by a bacterial streptococcii. Transmission is usually by the inhalation or ingestion of the infected discharges. It is highly contagious and the organisms may live outside the animal's body for as long as six months.

Glanders or farcy: A very old disease of bacterial origin. It may be diagnosed through the "mallein test." No cure is known.

Dourine: A chronic venereal disease of horses and asses commonly termed equine syphilis. It is caused by a protozoa and is spread mostly through mating, but may be transmitted by biting insects.

In 1930 the Bureau of Animal Industry reported that 17% of the wild horses on the San Carlos Apache Indian lands were infected with dourine. Later tests indicated 80% of the horses in the high country were infected. The Federal Bureau of Animal Husbandry removed about 500 horses from Nevada wild herds in

1935 because of the presence of the disease (Wyman, 1945). The Bureau of Land Management in 1974 reported a suspected outbreak of the same disease in wild horses near China Lake, California.

Rabies: caused by a filtrable virus which usually occurs from injected saliva in a bite wound; an acute infectious disease of horses and all other warm-blooded animals, including man.

Anthrax: also infectious to all warm-blooded animals. The bacillus of anthrax can survive in the soil for very long periods. It was the first disease in which immunization was accomplished by an attenuated culture by Pasteur in 1881.

Tetanus: Caused by an extremely powerful toxin liberated by the tetanus organisms (Clostridium tetanii). The organism is found in certain soils, horse dung, and sometimes in human excreta.

Periodic opthalmia, or moon blindness: the most common cause of blindness in horses and mules. It is an inflammation of the inner portion of the equine eye and its associated structures. Horses of all ages are susceptible, and it may occur in one or both eyes (Roby et al, 1956).

Parasites: The species and degree of harm vary in different parts of the world. They may be located in practically every tissue and cavity of the body. Some are specifically localized, others are migratory through different parts of the body. The most important of these are: the bot flies, of which there are three species; the strongyles with six species, the larger of which are commonly referred to as bloodworms or redworms; the ascarids or roundworms; two species of pinworms; four species of stomach worms; the screw worm, largely confined to the south and southwest; blowflies; ringworm; lice; mites; and ticks.

Poisonous plants: Horses often eat and may be poisoned by many species of poisonous plants. Some plants may be eaten over extended periods before producing ill effects, others that contain acute poisons may produce visible symptoms or death soon after being eaten (Huffman et al, 1956).

In addition, horses are subject to colds, laryngitis, bronchitis, pneumonia and pleurisy (Hanauer, 1973).

Competition and Relationships With Other Animals

Competition. The extent, nature and degrees of competition between wild horses and other domestic or wild animals for habitat components such as food, water, space and cover or other requirements has never been investigated. Cook (1968), writing on the nutritive content of range forage for domestic ruminants, stated that the most critical period for grazing animals that inhabit seasonal ranges are those months between December and April when inclement weather and perhaps poor range conditions cause animals to lose weight excessively. When range conditions are poor, the degree of utilization of the forage increases and the digestibility and nutrient content decreases because animals are forced to eat the less nutritious parts of the plants. Thus nutritional deficiencies are common on winter ranges of the intermountain region. The above would also apply to wild horses in varying degrees over much of their range. Since wild horses are on the range year round, at some season or seasons they occupy the same range as domestic livestock, elk, deer, and antelope. If, during these periods, forage is in short supply the various classes of herbivores will compete, and it is likely that the less dominant animals will suffer the most.

Hansen (1975) does not think that wild horses compete strongly with mule deer (Odocoileus hemionus) or antelope on most ranges, but he would expect them to compete with cattle since their diets appear to be 60 to 98 percent similar. They may compete moderately with domestic sheep, bighorn sheep (Ovis canadensis) and elk (Cervus canadensis).

Both the Bureau of Land Management and the Forest Service report competition between wild horses, domestic livestock, and big game animals. Generally these reports have centered around forage supply.

Cook (1975) states that in many areas where wild horses now occur the habitat is unsuitable for year-round feed requirements. Under the provisions of the Wild Horse Act they cannot be moved to suitable areas if that particular area did not previously contain wild horses. The author estimates that wild horses are increasing 20 to 30% per year, and under these conditions many of them will starve and the range will deteriorate. Cook feels that starvation, disease, and deterioration of the environment may not be acceptable management measures.

Relationships with other animals. Documented information on the relationships between wild horses and other animals is extremely scarce.

In 1828 a Mexican surveying party reported that between Laredo and San Antonio, Texas, deer and wild horses grazed together in large numbers. When wild horses were frightened and ran in large bands, they were sometimes joined by antelope (Antilocapra americana) (Dobie, 1952). Ryden (1970) stated that wild horses and buffalo (Bison americana) often grazed together and that antelope used the horses for sentries to warn them of danger. During severe winters cattle often followed the horse herds so they could graze in areas the horses had opened up. Other reports conflict with these statements. Linsdale and Tomich (1953) reported that mule deer (Odocoileus hemionus columbianus) moved away when horses grazed too close to them. Both Blakeslee (1974) and Tyler (1972) wrote that free-roaming appaloosas and semi-wild ponies, respectively, dominated cattle. Tyler observed a yearling pony threaten a fallow deer doe (Dama dama) that was grazing near it.

McKnight (1959) wrote that many of the respondents to his questionnaire stated that wild horses abused livestock, sometimes killing or crippling them and sometimes excluding them from watering places.

Wild Horse Management

(The following sections on Population Management and Population Control were contributed by Milton Frei of the Bureau of Land Management, Denver, Colorado.)

Population management. The management of wild horses presents a new challenge to public land administration agencies such as the Bureau of Land Management and the U. S. Forest Service. Heretofore management responsibilities of these agencies have been limited to animal habitat rather than the animals themselves.

Although the concept of wild horse population management is a relatively new one, the principles of animal population management are well documented and can be applied directly to wild horses.

The first step in managing wild horse populations is to determine the number of animals to manage in any particular area. The determination of this number must be based on available habitat and consideration of other animal species or resource values.

Once the number of wild horses to be retained for management has been determined, the next step is to analyze those factors which have molded the population into what it is today. It must be true that over the long run, as many wild horses die

as are born. This is the same scheme that nature has built into all of her animal species. Therefore, before management of wild horse populations can begin, the factors of population dynamics (productivity, mortality, sex ratio and age structure) must be collected and understood. These factors can then be analyzed to determine the forces which have shaped the population and to predict the numerical abundance of wild horses in the future.

The first step in a wild horse population analysis is to determine if the population is stable, increasing or decreasing. The following formula represents one method for determining the stability of a wild horse population:

A = Estimated number of adults in population (1 year and older)
B = Foal/100 adults (percent)
F = Number of foals
Zf = Mortality of foals (percent)
Nf = Mortality of foals (number)
Za = Mortality of adults (percent)
Na = Mortality of adults (number)
Y = Total population estimate (adults and foals)
P = Projected population
I = Population increase or decrease

$$(A)\ (B) = F$$
$$(F)\ (Zf) = Nf$$
$$(A)\ (Za) = Na$$

$$A + F = Y$$
$$Y - (Nf + Na) = P$$
$$P - A = I$$ (increase or decrease). If P is less than A, reverse P and A in formula. Values will then be decrease in population.

$\frac{I}{P}$ = Population increase where $P > A$

$\frac{I}{A}$ = Population decrease where $P < A$

Once the stability of a wild horse population has been determined, it is necessary to analyze other population data prior to actual manipulation of the population. For example, if the population is determined to be increasing in total numbers and it is desirable to decrease total numbers, an analysis can be made as to the ratio of male animals to female animals in the total population. It may be possible to decrease the productivity of wild horses by increasing the number of male animals in relation to the number of female animals.

In another example, if the population is determined to be stable, it is important to understand the reasons why. It may be that births are equalling deaths or that the population is on the brink of disaster. In this example, an analysis can be made as to the age structure of the population. If the age structure is balanced (i.e. all age classes adequately represented), nothing more in the way of management need be done. However, if one or more age classes are lacking or totally missing, it may indicate that the missing age classes must be restored if the population is to survive.

Population control. Control of wild horse populations differs from control of big game populations in that they are not a huntable or game species. Shooting of wild horses by persons other than officials of the Bureau of Land Management or U. S. Forest Service is prohibited by federal law and is socially unacceptable.

Control of wild horses is also restricted in that it is a violation of federal law to use aircraft or motorized vehicles to capture or kill a wild horse. As a result, the only techniques available to capture the animals alive involve time-consuming techniques such as water trapping, dry trapping, roping and immobilizing. This is complicated by the fact that many areas are too rough or have too many water sources for these techniques to be effective.

Disposing of wild horses which have been captured presents additional complications in population control. If animals are destroyed the problem arises as to what should be done with their carcasses. It is against federal law to convert the remains of wild horses into commercial use. If live animals are given away to private individuals for keeping under humane conditions, the problem arises as to transfer of title to the animal. It is not possible to transfer title to wild horses and as a result, many individuals are reluctant to keep a wild horse under those conditions. In addition, wild horses are just as their name suggests, "wild." Full-grown horses are very powerful animals and can be extremely dangerous when placed in the hands of unexperienced individuals.

Methods of capture. Hall (1974) has prepared a paper on wild horse capture techniques based primarily on experience gained during the herd reduction program on the Pryor Mountain wild horse range. Rather than attempt to repeat, the reader is referred to this publication. The author states that many of the methods described will prove too costly in terms of manpower and money to capture large numbers of horses for population reductions. However, as far as is known, this is the only publication of its kind in existence.

Other states, notably Wyoming, Nevada, and Oregon, have had experience in gathering wild horses. The Bureau of Land Management in Wyoming presented a paper to the National Advisory Board for wild, free-roaming horse and burros at their September 1974 meeting in Reno, Nevada on the techniques and problems of wild horse capture.

The methods used to capture wild horses after World War II and prior to the enactment of PL 92-195 have been described elsewhere. Methods of capture used by the early horse catchers included creasing, roping, snaring and running the animals into some type of corral or trap. Shooting a horse in the upper part of the neck close to the spinal column was termed creasing. The shock stunned the animal so that he was immobile until he could be tied. The method was more legend than truth. Old mustangers related that for every horse caught by this method fifty were killed. Horses were snared by attaching a loop of rope to a long pole. The rider rode alongside the horse and dropped the loop over his head. He then dismounted and choked the horse to the ground. Lassoing or roping did not become a common method of capture until late in the 19th century. Corrals or traps were of all types, depending upon the available material and the topography such as narrow canyons or ravines. Brush was often piled fan shaped as wings to guide the horses into the trap (Dobie, 1952).

Hoyt (1886) describes wild horse capture techniques on the Texas panhandle. The horses were chased for 5 or 6 days by relays of saddle horses and riders until they were so exhausted they would mill rather than run when a rider approached. They were then roped and clog chains attached to their legs. Part of the clog was a free length of chain which wrapped itself around the forelegs if the horse attempted to run. All horses except yearlings and two-year-olds were clogged. The stallions were captured first and castrated at the time the clogs were attached. The horses were driven to water once a day and allowed to graze only at night so that they would spend the hours of darkness eating rather than attempting to escape.

Ryden (1970) was told by old timers that early mustangers in the Wyoming Red Desert captured wild mares, tamed them, then sewed their nostrils together with rawhide until they could only partially breathe. The mares were then released to run with their old band. Since they could not run fast they slowed the whole band and the horses were easier to capture. Another method used was to bend a horseshoe around a captured mare's ankle and then release her. The horseshoe did not bother her when she walked but when she ran it banged against her other legs and slowed her. These mares were used over and over again.

Both James and Catlin writing in 1823 and 1838, respectively, relate that the Comanches could tame and ride a wild horse within a day or so of capture. A small party of well-mounted Indians would hide in a narrow ravine or some other concealed area while the other members of the tribe would drive the horses into the ambush area. Each horse was captured with a lasso or noosed rope around the neck. They were then quickly thrown and their heels tied together.

Wild horse management plans. Both the U. S. Forest Service and the Bureau of Land Management have developed plans for protection, management and control of wild horses. Both agencies have land use planning systems that evaluate the resource and then develop integrated planning and management for all the multiple uses of the land area under consideration. These include the vegetative and watershed conditions, wildlife needs, livestock use, recreational use, and other legitimate demands.

Current problems. From various reports these include: rapidly expanding populations that, due to the restrictions of PL 92-195, will demand costly and inefficient means of control; lack of biological data on wild horses; lack of valid censusing and population data; lack of funds and manpower needed for intense management; competition between livestock, elk, deer, and antelope for forage and habitat; problems of disposing of excess horses; management and control of horses on intermingled lands (federal, private, state or other ownership); stallions stealing privately owned mares; highway hazards (Wyoming Bureau of Land Management reports that at least 10 horses were killed by cars in 1974); and recreationists have complained of being chased by wild horses.

Cook (1975) concluded that the Wild Horse and Burro Act was short sighted. The bill essentially has no control measures and as a result wild horses will continue to increase to the detriment of the resource; the bill should be amended to permit the use of aircraft by the agencies for roundups and control; the excess horses cannot be sold or given away; and there is no provision to permit complete removal of horses from some areas of unsuitable year-round habitat.

Advantages of wild horses. There are certain advantages to having wild horses on the range. Due to their inefficient digestive system they aid in spreading plants by the distribution of feces that contain viable seeds. Their feces distribution also fertilizes the soil and aids germination of seeds. Horses aid livestock and other herbivores by breaking ice covering water holes in the winter and help all animals by breaking trails through snow. They provide an esthetic value to the western range that has never been exceeded by any other animal (Dobie, 1952; McKnight, 1959; Ryden, 1970). Horses

graze very selectively and can utilize grasses too coarse for most other domestic animals (Stoddart et al, 1975). The removal of coarse forage material exposes finer, more succulent feed for other herbivores. Frei (1975) claims that wild horses use range lands more efficiently than cattle. They travel much greater distances in search of forage and do not excessively utilize vegetation near water because they do not remain near watering sources for long periods like cattle.

Disadvantages of wild horses. McKnight (1959) listed about a dozen problems associated with wild horse from respondents to his questionnaire. Heading the list was competition with livestock for forage and water. Other problems were competition with big game, overgrazing, trampling, heavy grazing during the spring, leading tame horses into the wilds, destroying range improvements, tearing down fences, excluding other animals from water, molesting livestock, roiling or dirtying water holes, and breaking into cropland and grazing. Stoddart et al (1975) states that horses constantly seek fresh feed and are capable of cropping forage very closely because they have both upper and lower incisor teeth. When horses are confined in small pastures no other animal can match their impact.

Research needs. All aspects of wild horse ecology need research, and so it is difficult to assign priorities. However, if management of wild horses is to be meaningful to the land managers in the near future, it would appear that research into year-round habitat requirements would assume great importance. Also desperately needed are data on population dynamics and competition with other animals.

Current research. At present neither the Department of Agriculture nor of the Interior are funding any research on wild horses. Eastern Montana College at Billings, Montana, and Colorado State University at Fort Collins, Colorado, are presently engaged in wild horse research that is privately funded. Results have not as yet been published.

Designated wild horse ranges. In 1962 the Secretary of the Interior established a 435,000-acre refuge for wild horses in southern Nevada. The area is northwest of Las Vegas in the northeast corner of Nellis Air Force Base.

In 1968 the Secretary of the Interior established a 31,000-acre wild horse range in the Pryor Mountains of south-central Montana. The area adjoins the Wyoming state line and the Bighorn Canyon National Recreation Area.

Legislation concerning wild horses and burros. Congress has passed two Federal laws to protect wild horses. Public Law 86-234, passed in 1959, makes it illegal to use aircraft or motorized vehicles to capture or kill wild horses. Public Law 92-195, passed in 1971, places wild horses and burros roaming on national resource lands under the jurisdiction of the Secretaries of the Interior and of Agriculture Departments for protection, management and control. It provides a penalty for harassing, capturing, killing, or selling wild horses, and prohibits the processing of wild horses into any commercial product. The maximum penalty consists of a fine of $2,000 and imprisonment for one year. The Act of 1971 provides for the establishment of an advisory board to make recommendations on the management and protection of wild horses and burros.

Under the laws of the various states, wild horses are not recognized as game animals or wildlife. They are considered as "estrays" or abandoned animals and are not included under the provisions of the Taylor Grazing Act.

Cooperative agreements for the protection and management of wild horses and burros are authorized between the Secretaries of Interior or Agriculture and state and local government agencies and with other landowners.

Organizations concerned with the welfare of wild horses. The inclusion of all the people, groups, animal welfare organizations or others that have aided and supported the wild horse cause would be extremely lengthy. Therefore, the organizations listed below include only those that are directly and exclusively concerned with the preservation and welfare of the wild horse.

1. American Horse Protection Association
   Washington, D. C. 20007

2. American Mustang Association
   Phoenix, Arizona

3. Canadian Wildhorse Society
   Richmond, British Columbia

4. International Society for the Protection of Mustangs and Burros
   Reno, Nevada

5. National Mustang Association
   Newcastle, Utah 84756

6. Spanish Barb Wild Horse Research Farm
   248 N. Main Street
   Porterville, California 93257

7. The Spanish Mustang Registry
   Oshoto, Wyoming

8. Wild Horse Organized Assistance
   Reno, Nevada

Glossary. All modern horse breeds are called either hot, cold, or warm bloods. The hot bloods, small, swift and temperamental developed from the Arab horse. The cold blood, larger, more placid, developed in northern Europe during the middle ages to carry armored knights. The warm bloods are a mixture of the two (Ryden, 1970).

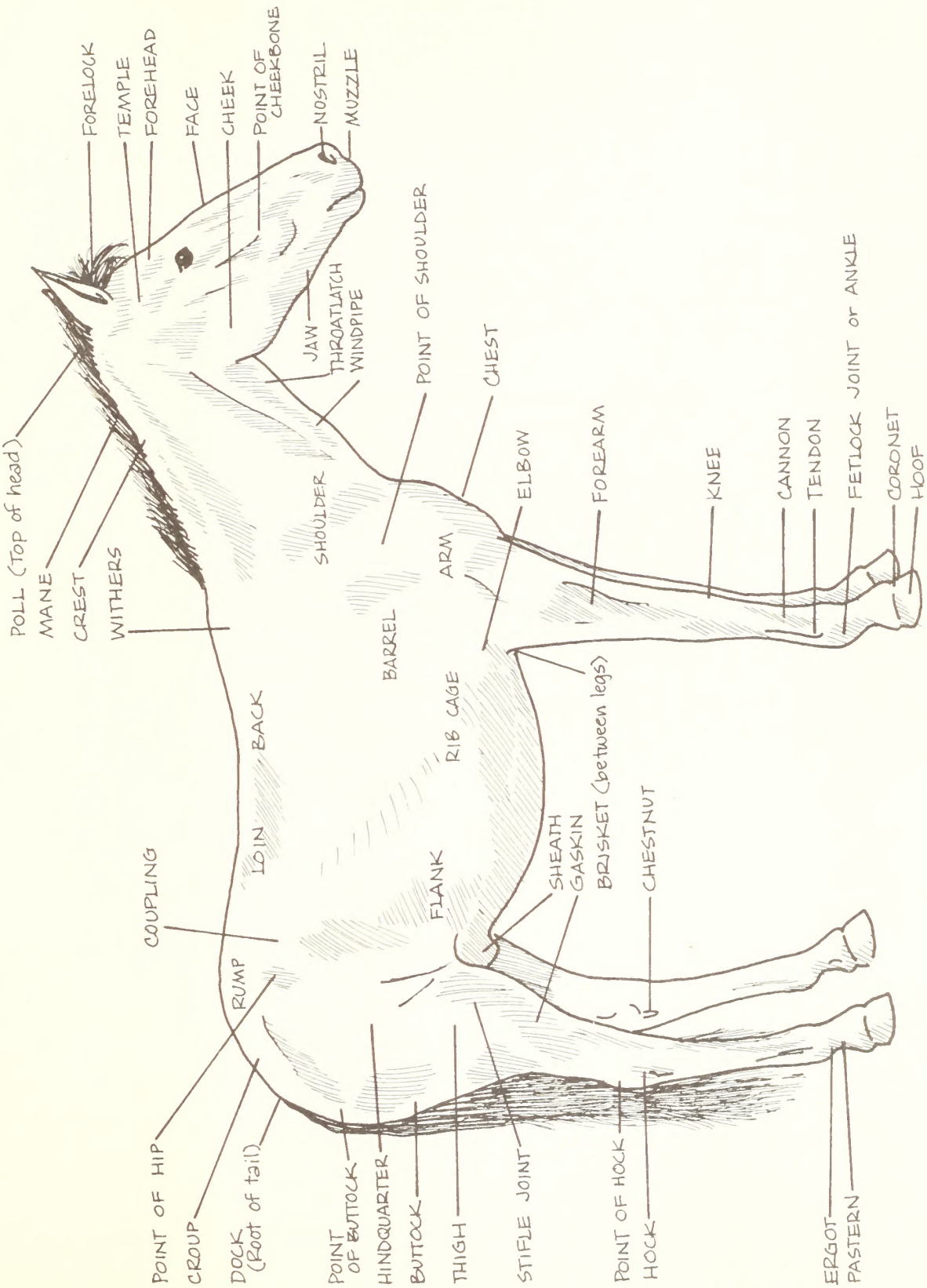
Hand - the system of measuring a horse's height. A hand is four inches or the width of an adult man's hand across the thumb. The term dates back to ancient times (Howard, 1965).

Mustang - a corruption of the Spanish word Mesteño, which refers to an animal that belongs to everyone and not to any particular person. The term was first applied to horses that had escaped and became wild in the Southwest. In a short time all feral and semi-feral horses were referred to as mustangs. The name was also applied to certain domesticated horses. When feral horses were caught and broken, the word also came to mean cow pony (McKnight, 1959).

Cayuse - the term applied to any horses that resembled Indian stock or to cow ponies that were wild. The name originated from the Cayuse Indians of Idaho (a tribe now extinct) who were known for the numbers of horses they possessed (Dobie, 1952).

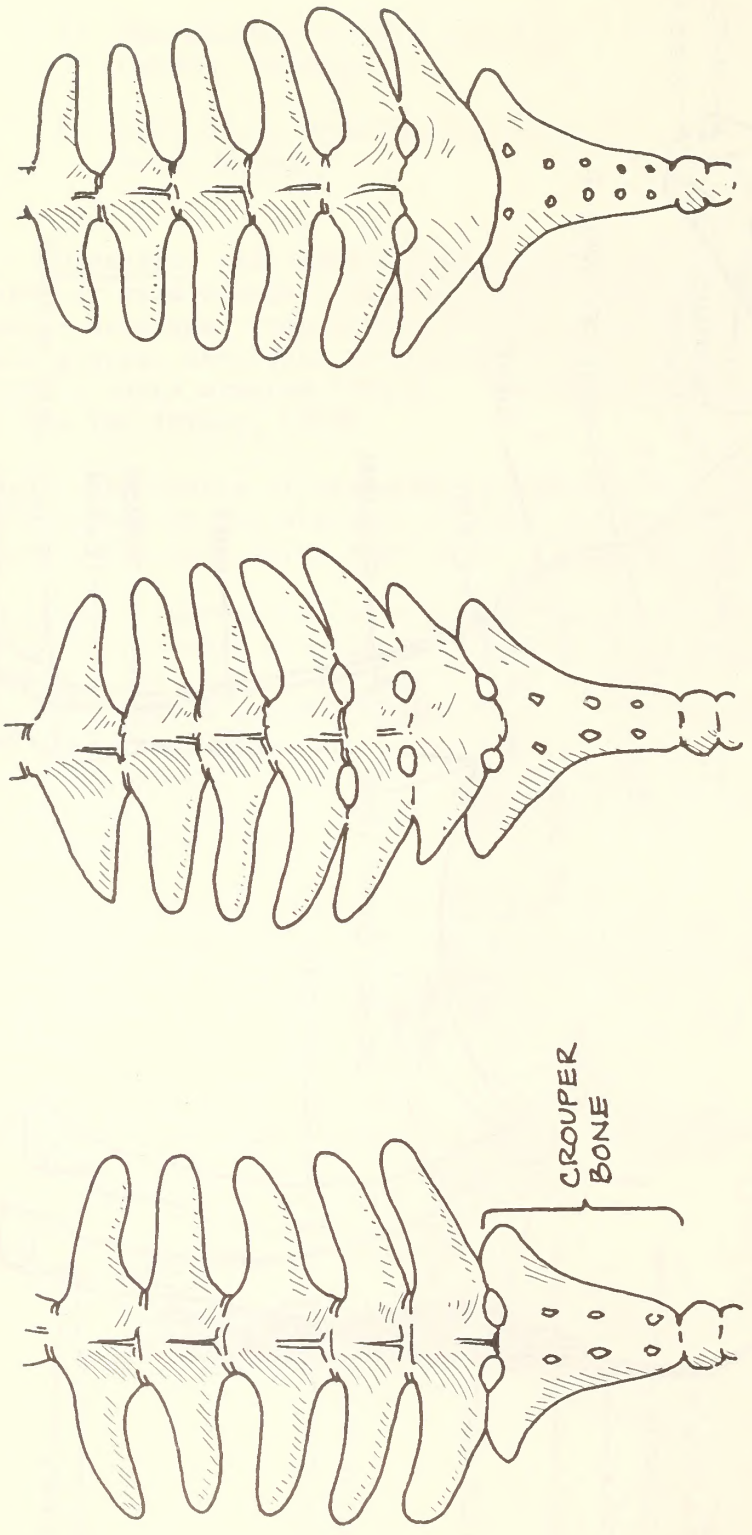
Estray - "any steer, heifer, bull, stag, cow, calf, horse, mare, gelding, or colt not wearing a brand (Ryden, 1970).

APPENDIX 1
Labeled Points or Parts of a Horse



LABELED POINTS OR PARTS OF A HORSE

APPENDIX 2
Three Types of Lumbar Vertebrae Found in Horses



THREE TYPES OF LUMBAR VERTEBRAE FOUND IN HORSES

APPENDIX 3
Coat Colors in Horses
Adapted from Gremmel, 1939

A. Basic Colors

I. Black - body color is true black (disregarding weathering):
1. Black - true black without light areas
2. Seal brown - black with light areas to include muzzle, under eyes, flank, and inside of upper legs, termed "light points."

II. Bay - shades from tan to brown, with black mane and tail and often with black lower legs:
1. Mahogany bay - the brown shades of bay, often called brown
2. Blood bay - the red shades of bay
3. Sandy bay - the light shades of bay

III. Chestnut - shades from yellow gold to dark brown, mane and tail not black but approximately the color of the body:
1. Liver chestnut - the dark shades, some appearing dark brown with an auburn hue
2. Sorrel - the red shades; sometimes in the lighter shades the mane and tail are of the color described as "crushed strawberry."

IV. Ysabella - a color group having flax or silver manes and tails:
1. Red ysabella - red sorrel-like; flax mane and tail
2. Palomino - a golden yellow; silver mane and tail
3. Pseudo-albino - very light cream to white; silver mane and tail; often have "glass" or blue eyes

B. Color Patterns

I. Gray - causes gradual displacement of colored hair by white hair as age advances:
1. Iron or steel gray - usually a high percentage of colored hair, indicating a young animal
2. Dapple gray - having the colored hair in such distribution as to give a dappled effect
3. White - almost devoid of colored hair

II. At certain ages gray, black roan, and gray roan are practically indistinguishable, but true genetic differences exist. Gray is foaled solid color; any roan is foaled roan; and gray roan whitens with age the same as does gray.

Roan, a more or less uniform mixture of colored and white hairs, occurs in a number of combinations:

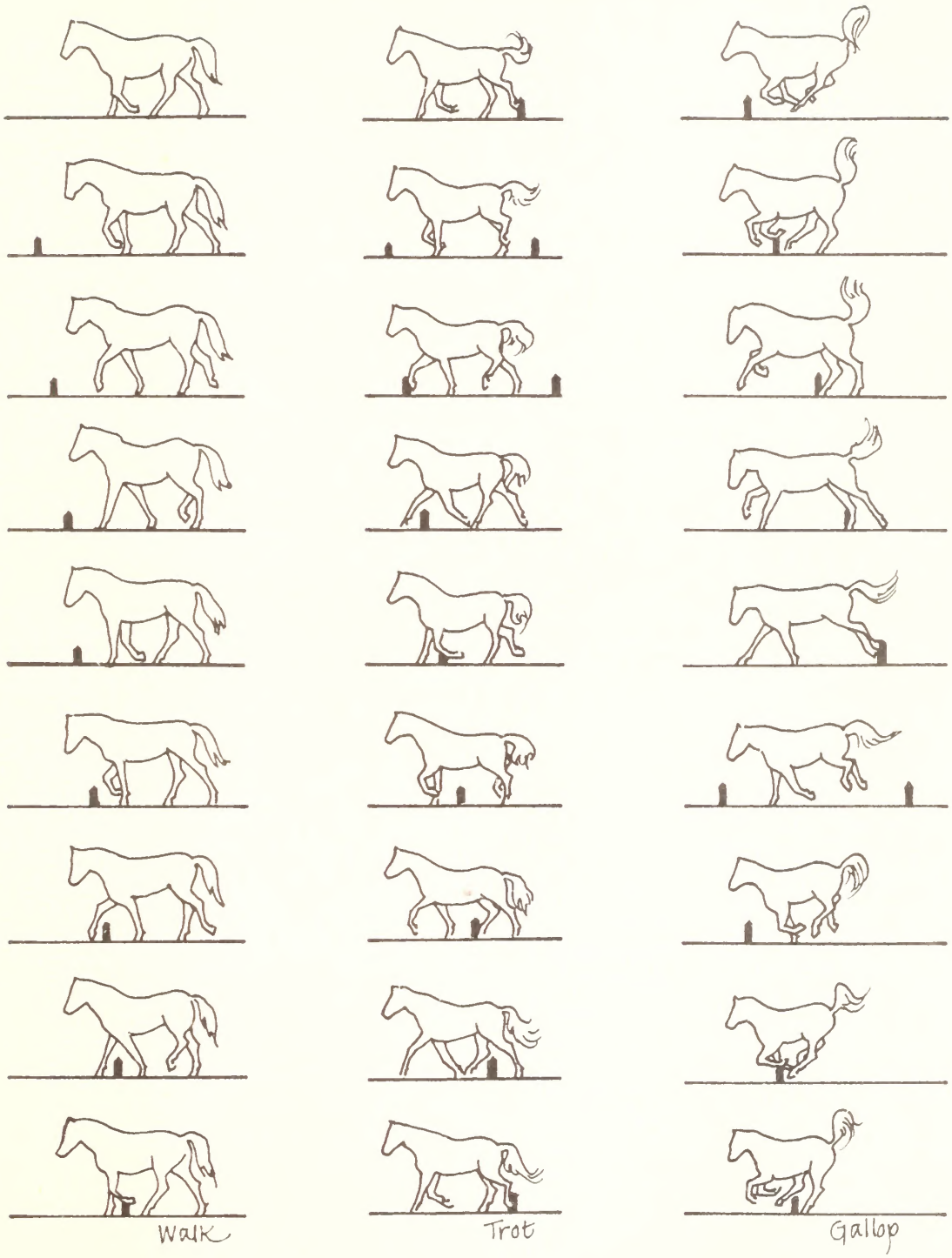
1. Black roan - black and white hairs mixed, usually called "blue."
2. Blue roan - usually described as black and white hairs mixed, but almost invariably having some red hairs.
3. Bay or red roan - roaned bay.
4. Chestnut or strawberry roan - roaned chestnut.
5. Paint roan - roaning imposed on the colored areas of paint.
6. Dun roan - roan in combination with the dun factor
7. Gray roan - roan in combination with the gray factor.

III. Dun - always with dorsal stripe; often zebra stripes on legs and transverse stripe over withers and shoulders; coat appears diluted:
1. Mouse dun - dun imposed on black, seal brown, dark mahogany bay, and dark liver chestnut, giving a smoky effect.
2. Buckskin dun - dun imposed on blood and sandy bay.
3. Claybank dun - dun imposed on sorrel.

IV. Paint or pied - irregular colored and white areas:
1. Piebald - white and black
2. Skewbald - white and any color other than black

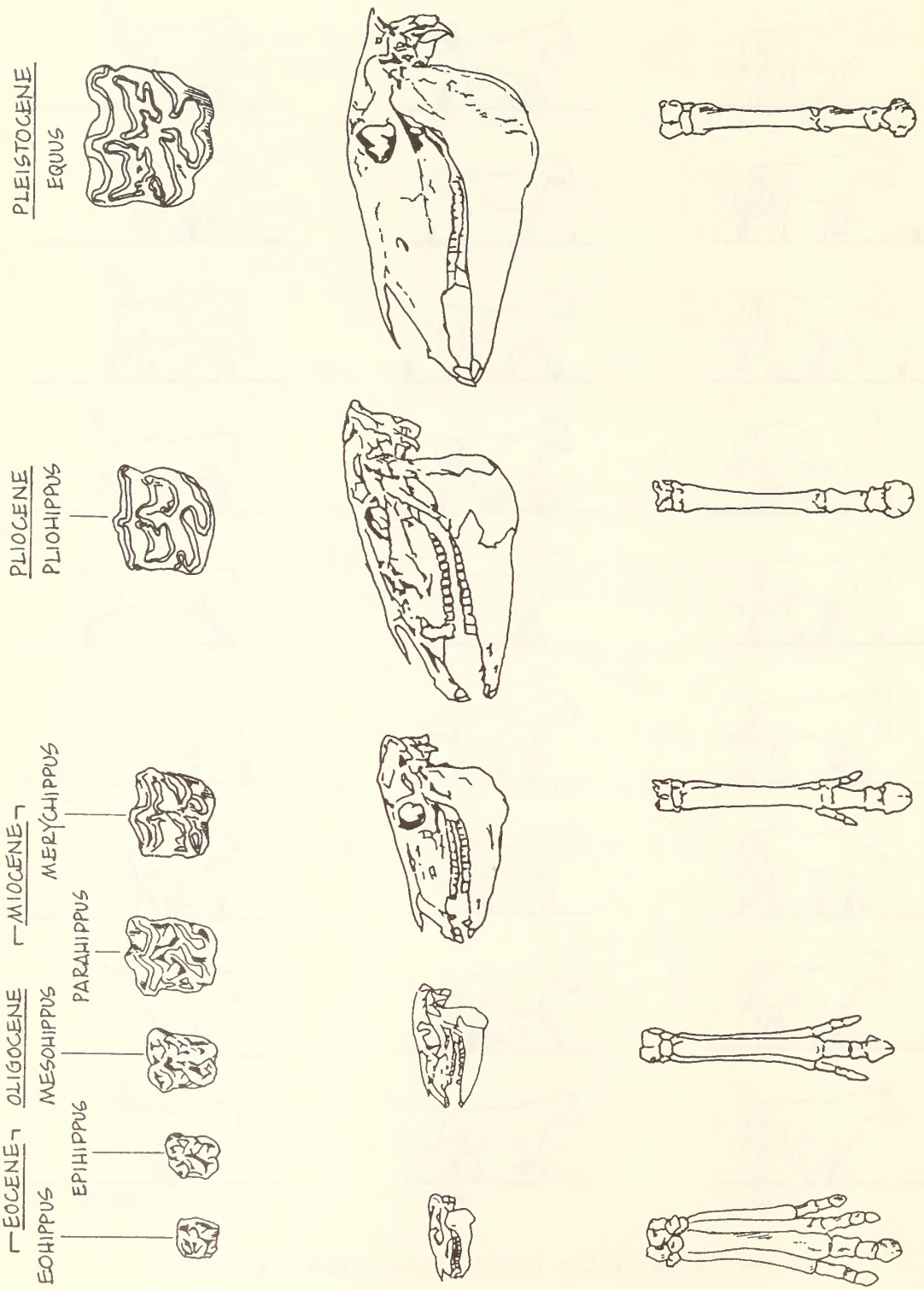
Gray, roan, dun, and pied or paint may be in any combination.

APPENDIX 4
Movement on Land
Adapted from Tricker and Tricker, 1966



Three Gaits of the Horse, Drawn from Ciné Film

APPENDIX 5
Evolution of the Horse: Teeth, Skulls and Feet
Adapted from World of Wildlife



APPENDIX 6

Plant Species Comprising at Least 2% or More of the Diet of Wild Horses in the Southwest Desert Vegetation Types Adapted from Hansen, 1975

Scientific Name	Common Name
Agropyron spp.	wheatgrasses
Bouteloua spp.	grama grasses
Hilaria mutica	Tobosa grass
Koelaria cristata	prairie junegrass
Leptochloa dubia	green spangletop grass
Muhlenbergia spp.	muhly grass
Setaria macrostachya	plains bristlegrass
Sporobolus spp.	dropseed grass
Atriplex spp.	saltbush
Prosopsis juliflora	mesquite
Salsola spp.	russian thistle

Plant Species Comprising at Least 2% or More of the Diet of Wild Horses for the Foothills and Northern Desert Shrub Vegetation Types in Western States

Agropyron spp.	wheatgrasses
Bromus spp.	brome grass
Carex spp.	sedges
Juncus spp.	rushes
Elymus spp.	wildrye grass
Festuca spp.	fescue grass
Koelaria cristata	prairie junegrass
Oryzopsis hymenoides	Indian ricegrass
Poa spp.	bluegrass
Stipa spp.	needle and thread grass
Allium spp.	wild onion
Amelanchier spp.	service berry
Artemisia frigida	fringed sagewort
Artemisia spp.	sagebrushes
Cercocarpus spp.	mountain mahogany
Chrysothamus spp.	rabbitbrush
Eriogonum spp.	buckwheat
Eurotia lanata	winterfat
Leptodactylon spp.	prickly phlox
Lupinus spp.	lupine
Phlox spp.	phlox

APPENDIX 7
The Spread of the Horse to the Western World
Adapted from Smith, 1969

to the western world

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